







LM4040-N/-Q1 Precision Micropower Shunt Voltage Reference

1 Features

TEXAS

- SOT-23 AEC Q-100 Grades 1 and 3 Available
- Small Packages: SOT-23, TO-92, and SC70
- No Output Capacitor Required
- **Tolerates Capacitive Loads**
- Fixed Reverse Breakdown Voltages of 2.048 V, 2.5 V, 3 V, 4.096 V, 5 V, 8.192 V, and 10 V
- Key Specifications (2.5-V LM4040-N)
 - Output Voltage Tolerance (A Grade, 25°C): ±0.1% (Maximum)
 - Low Output Noise (10 Hz to 10 kHz): $35 \mu V_{rms}$ (Typical)
 - Wide Operating Current Range: 60 µA to 15
 - Industrial Temperature Range: −40°C to +85°C
 - Extended Temperature Range: -40°C to
 - Low Temperature Coefficient: 100 ppm/°C (Maximum)

2 Applications

- Portable, Battery-Powered Equipment
- Data Acquisition Systems
- Instrumentation
- **Process Controls**
- **Energy Management**
- Product Testing
- Automotives
- Precision Audio Components

3 Description

Ideal for space-critical applications, the LM4040-N precision voltage reference is available in the subminiature SC70 and SOT-23 surface-mount package. The advanced design of the LM4040-N eliminates the need for an external stabilizing capacitor while ensuring stability with any capacitive load, thus making the LM4040-N easy to use. Further reducing design effort is the availability of several fixed reverse breakdown voltages: 2.048 V. 2.5 V. 3 V. 4.096 V. 5 V, 8.192 V, and 10 V. The minimum operating current increases from 60 µA for the 2.5-V LM4040-N to 100 uA for the 10-V LM4040-N. All versions have a maximum operating current of 15 mA.

The LM4040-N uses a 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.

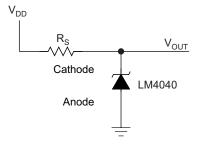
Also available is the LM4041-N with two reverse breakdown voltage versions: adjustable and 1.2 V. See the LM4041-N data sheet (SNOS641).

Device Information(1)

	PART NUMBER	PACKAGE	BODY SIZE (NOM)
		TO-92 (3)	4.30 mm × 4.30 mm
	LM4040-N	SC70 (5)	2.00 mm × 1.25 mm
		SOT-23 (3)	2.92 mm × 1.30 mm
	LM4040-N-Q1	SOT-23 (3)	2.92 mm × 1.30 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Shunt Reference Application Schematic



LM4040-N, LM4040-N-Q1

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

C	hanges from Revision J (August 2015) to Revision K	Page
<u>.</u>	Updated pinout diagrams	4
С	hanges from Revision I (April 2015) to Revision J	Page
<u>C</u>	hanges from Revision I (April 2015) to Revision J Added ESD Ratings table, Feature Description section, Device Functional Modes section, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and Documentation	Page

Changes from Revision G (July 2012) to Revision H

Changes from Revision H (April 2013) to Revision I

Page

Page

Added some of the latest inclusions from new TI formatting and made available of the automotive grade for the

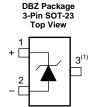
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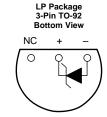


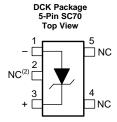
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5 Pin Configuration and Functions







Pin Functions

Till Tullottolis										
		PIN		1/0	DESCRIPTION					
NAME	SOT-23	TO-92	SC70	1/0	DESCRIPTION					
Anode	2	1	1	0	Anode pin, normally grounded					
Cathode	1	2	3	I/O	Shunt Current/Output Voltage					
NC	3 ⁽¹⁾	_	2 ⁽²⁾	_	Must float or connect to anode					
NC	_	3	4, 5	_	No connect					

(1) This pin must be left floating or connected to pin 2.(2) This pin must be left floating or connected to pin 1.

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6 Specifications

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6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)(2)

		MIN	MAX	UNIT
Reverse current			20	mA
Forward current			10	mA
	SOT-23 (M3) package		306	mW
Power dissipation (T _A = 25°C) ⁽³⁾	TO-92 (Z) package		550	mW
20 0)	SC70 (M7) package		241	mW
	TO-92 (Z) package SC70 (M7) package SOT-23 (M3) Package Peak Reflow (30 sec) TO-92 (Z) Package Soldering (10 sec) SC70 (M7) Package Peak Reflow (30 sec)		260	°C
Soldering temperature (4)	TO-92 (Z) Package Soldering (10 sec)		260	°C
SC70 (M7) package 241 SOT-23 (M3) Package Peak Reflow (30 sec) 260 TO-92 (Z) Package Soldering (10 sec) 260	°C			
Storage temperature		-65	150	°C

- (1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (3) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), R_{BJA} (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)/R_{BJA} or the number given in the *Absolute Maximum Ratings*, whichever is lower. For the LM4040-N, T_{Jmax} = 125°C, and the typical thermal resistance (R_{BJA}), 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.
- (4) For definitions of Peak Reflow Temperatures for Surface Mount devices, see the TI Absolute Maximum Ratings for Soldering Application Report (SNOA549).

6.2 ESD Ratings

			VALUE	UNIT
		Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)		
V _(ESD)	Electrostatic discharge	Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±200	V

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

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6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)(1)(2)

		MIN	MAX	UNIT
Temperature	Industrial Temperature	-40°C ≤ T _A ≤ 85		°C
$(T_{min} \le T_A \le T_{max})$	Extended Temperature	-40 ≤ T _A ≤ 125°C		°C
	LM4040-N-2.0	60	15	μA to mA
	LM4040-N-2.5	60	15	μA to mA
	LM4040-N-3.0	62	15	μA to mA
Reverse Current	LM4040-N-4.1	68	15	μA to mA
	LM4040-N-5.0	74	15	μA to mA
	LM4040-N-8.2	91	15	μA to mA
	LM4040-N-10.0	100	15	μA to mA

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Recommended Operating Conditions indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
- (2) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), R_{BJA} (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)/R_{BJA} or the number given in the Absolute Maximum Ratings, whichever is lower. For the LM4040-N, T_{Jmax} = 125°C, and the typical thermal resistance (R_{BJA}), 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.

6.4 Thermal Information

		LM4			
	THERMAL METRIC ⁽¹⁾	DBZ (SOT-23)	LP (TO-92)	DCK (SC70)	UNIT
		3 PINS	3 PINS	5 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	291.9	166	267	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	114.3	88.2	95.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	62.3	145.2	48.1	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	7.4	32.5	2.4	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	61	N/A	47.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	N/A	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application

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6.5 Electrical Characteristics: 2-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature Grade 'I'

all other limits $T_A = T_J = 25$ °C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of $\pm 0.1\%$ and $\pm 0.2\%$, respectively.

	PARAMETER		TEST CONDITIONS		MIN ⁽¹⁾	TYP	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	Ι _R = 100 μΑ				2.048		٧
	Reverse Breakdown		LM4040AIM3 LM4040AIZ				±2	
V_{R}		rse Breakdown	LM4040BIM3 LM4040BIZ LM4040BIM7				±4.1	mV
	Voltage Tolerance (2)	Ι _R = 100 μΑ	LM4040AIM3 LM4040AIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±15	
			LM4040BIM3 LM4040BIZ LM4040BIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±17	mV
	Minimum Operating		$T_A = T_J = 25$ °C			45	60	μA
I _{RMIN}	Current		$T_A = T_J = T_{MIN}$ to T_{MAX}				65	μΑ
	Average Reverse Breakdown Voltage	$I_R = 10 \text{ mA}$				±20		ppm/°C
ΔV _R /ΔΤ		I _R = 1 mA	$T_{A} = T_{J} = 25^{\circ}C$			±15		ppm/°C
7 1 K/ 7 1	Temperature Coefficient ⁽²⁾	1R = 1 111/1	$T_A = T_J = T_{MIN}$ to T_{MAX}				±100	ррпі, С
	Cocmoient	$I_R = 100 \mu A$				±15		ppm/°C
	Reverse Breakdown	$I_{RMIN} \le I_R \le 1 \text{ mA}$	$T_A = T_J = 25$ °C			0.3	0.8	mV
$\Delta V_R/\Delta I$	Voltage Change with	tage Change with		$T_A = T_J = T_{MIN}$ to T_{MAX}			1	1110
R	Operating Current Change (3)	1 mA ≤ I _R ≤ 15 mA	$T_A = T_J = 25$ °C			2.5	6	mV
	Chango	1 1111/2 1g = 10 1111/	$T_A = T_J = T_{MIN}$ to T_{MAX}				8	111.4
Z_R	Reverse Dynamic Impedance	I _R = 1 mA, f = 120 Hz, I _{AC} = 0.1 I _R				0.3	0.8	Ω
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 (4)	$\Delta T = -40$ °C to 125°C				0.08%		

- Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- (2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±((ΔV_R/ΔT)(maxΔT)(V_R)]. Where, ΔV_R/ΔT is the V_R temperature coefficient, maxΔT 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 overtemperature tolerance for the different grades in the industrial temperature range where maxΔT = 65°C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65°C$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below: C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100$ ppm/°C × 100 °C

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100 ^{\circ}\text{C}$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ± 2.5 V \times 0.75% = ± 19 mV.

(3) 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.

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(4) 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.





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6.6 Electrical Characteristics: 2-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'I'

all other limits $T_A = T_J = 25$ °C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and $\pm 2\%$, respectively.

F	PARAMETER		TEST CONDITI	ONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	I _R = 100 μA				2.048		V
			LM4040CIM3	$T_A = T_J = 25$ °C			±10	
			LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±23	
V_R	Reverse Breakdown	Ι _R = 100 μΑ	LM4040DIM3	$T_A = T_J = 25^{\circ}C$			±20	mV
	Voltage Tolerance (3)	Ι _R = 100 μΑ	LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±40	IIIV
			LM4040EIZ	$T_A = T_J = 25^{\circ}C$			±41	
			LM4040EIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±60	
			LM4040CIM3	$T_A = T_J = 25$ °C		45	60	
		g	LM4040CIZ LM4040CIM7	$T_{A}=T_{J}=T_{MIN} \ to \ T_{MAX}$			65	
	Minimum Operating		LM4040DIM3 LM4040DIZ LM4040DIM7	$T_A = T_J = 25$ °C		45	65	μA
I _{RMIN}	Current			$T_A = T_J = T_{MIN}$ to T_{MAX}			70	μΑ
			LM4040EIZ	$T_A = T_J = 25^{\circ}C$		45	65	
			LM4040EIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			70	
		I _R = 10 mA				±20		
			LM4040CIM3	$T_A = T_J = 25$ °C		±15		
	A	_	LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±100	
A)/ /AT	Average Reverse Breakdown Voltage	l = 1 mΛ	LM4040DIM3	$T_A = T_J = 25^{\circ}C$		±15		nnm/°C
ΔVR/ΔI	Temperature Coefficient ⁽³⁾	I _R = 1 mA	LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	ppm/°C
			LM4040EIZ	$T_A = T_J = 25^{\circ}C$		±15		
			LM4040EIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	
ΔV _R /ΔT		I _R = 100 μA				±15		

- (1) Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
-) Typicals are at T_J = 25°C and represent most likely parametric norm.
- 3) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[(ΔV_F/ΔT)(maxΔT)(V_R)]. Where, ΔV_R/ΔT is the V_R temperature coefficient, maxΔT 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 overtemperature tolerance for the different grades in the industrial temperature range where maxΔT = 65°C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/}^{\circ}\text{C} \times 65^{\circ}\text{C}$ B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/}^{\circ}\text{C} \times 65^{\circ}\text{C}$ C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/}^{\circ}\text{C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/}^{\circ}\text{C} \times 65^{\circ}\text{C}$ E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/}^{\circ}\text{C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$ D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$ E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

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



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Electrical Characteristics: 2-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'I' (continued)

all other limits $T_A = T_J = 25$ °C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and +2% respectively

ı	PARAMETER		TEST CONDITIO	ONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
			LM4040CIM3 LM4040CIZ LM4040CIM7	$T_A = T_J = 25$ °C $T_A = T_J = T_{MIN}$ to T_{MAX}		0.3	0.8	
		I _{RMIN} ≤ I _R ≤ 1 mA	LM4040DIM3	$T_A = T_J = 25$ °C		0.3	1	
			LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.2	
	Reverse Breakdown		LM4040EIZ	$T_A = T_J = 25$ °C		0.3	1	
$\Delta V_R/\Delta I_R$	Voltage Change		LM4040EIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.2	mV
ΔVR/ΔIR	with Operating Current Change ⁽⁴⁾		LM4040CIM3	$T_A = T_J = 25$ °C		2.5	6	1117
	ouncil orlange		LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			8	
		1 mA ≤ I _R ≤ 15 mA	LM4040DIM3 LM4040DIZ LM4040DIM7	$T_A = T_J = 25$ °C		2.5	8	
				$T_A = T_J = T_{MIN}$ to T_{MAX}			10	
			LM4040EIZ	$T_A = T_J = 25$ °C		2.5	8	
			LM4040EIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			10	
			LM4040CIM3 LM4040CIZ LM4040CIM7			0.3	0.9	
Z _R	Reverse Dynamic Impedance		LM4040DIM3 LM4040DIZ LM4040DIM7			0.3	1.1	Ω
			LM4040EIZ LM4040EIM7			0.3	1.1	
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 (5)	$\Delta T = -40$ °C to 125°C				0.08%		

- (4) 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.
- 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.





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6.7 Electrical Characteristics: 2-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'E'

all other limits $T_A = T_J = 25$ °C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and ±2%, respectively.

	PARAMETER		TEST CONDITI	ONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	Ι _R = 100 μΑ				2.048		V
			LMAGAGOEMG	$T_A = T_J = 25^{\circ}C$			±10	
	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	±30						
V_R	Reverse Breakdown	1 4004	LMAGAGDEMO	$T_A = T_J = 25^{\circ}C$			±20	mV
	Voltage Tolerance (3)	I _R = 100 μA	LM4040DEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±50	mv
			LMAGAGEEMS	$T_A = T_J = 25^{\circ}C$			±41	
			LIVI4040EEIVI3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±70	
			LMAGAGOEMG	$T_A = T_J = 25^{\circ}C$		45	60	
			LIM4040CEIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			68	
	Minimum Operating			$T_A = T_J = 25^{\circ}C$		45	65	
I _{RMIN}	Current		LM4040DEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			73	μA
				$T_A = T_J = 25^{\circ}C$		45	65	
			LM4040EEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			73	
		I _R = 10 mA				±20	±41 ±70 60 68 65 73 65 73 ±100 ±150 0.8 1 1.2 1	
	Average Reverse Breakdown Voltage Temperature			$T_A = T_J = 25^{\circ}C$		±15		
	_		LM4040CEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±100	
$V_R/\Delta T \begin{tabular}{l l} $T_A = T_J = T_{MIN} \ to \ T_{MAX} \\ \hline \\ V_R/\Delta T \begin{tabular}{l l} $I_R = 10 \ mA \end{tabular} \begin{tabular}{l l} $I_R = 10 \ mA \end{tabular} \begin{tabular}{l l} $I_R = 10 \ mA \end{tabular} \begin{tabular}{l l} $LM4040CEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l l} $LM4040DEM3 \end{tabular} \begin{tabular}{l} $T_A = T_J = 25^\circ C \end{tabular} \begin{tabular}{l} $T_A = T_$								
ΔV _R /Δ I	Temperature	I _R = 1 mA	LM4040DEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	ppm/°
	Coefficient			$T_A = T_J = 25^{\circ}C$		±15		
			LM4040EEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	
		I _R = 100 μA				±15		
				$T_A = T_J = 25^{\circ}C$		0.3	0.8	
			LM4040CEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1	
				$T_A = T_J = 25^{\circ}C$		0.3	1	
		$I_{RMIN} \le I_R \le 1 \text{ mA}$	LM4040DEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.2	
				$T_A = T_J = 25^{\circ}C$		0.3	1	
$\Delta V_R/\Delta I$			LM4040EEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.2	
R R	Operating Current					2.5	6	mV
	Change (**)		LM4040CEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			8	
						2.5	8	
		$1 \text{ mA} \le I_R \le 15 \text{ mA}$	LM4040DEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			10	-
						2.5	8	
			LM4040EEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			10	

- (1) Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- Typicals are at T_J = 25°C and represent most likely parametric norm.
- The overtemperature 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 ΔT is the maximum difference in temperature from the reference point of 25°C to T MIN or TMAX, and V_R is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where max $\Delta T = 65$ °C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below: C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100°C$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x

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.

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LM4040-N, LM4040-N-Q1

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Electrical Characteristics: 2-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'E' (continued)

all other limits $T_A = T_J = 25$ °C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and ±2%, respectively.

	PARAMETER		TEST CONDITIONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
			LM4040CEM3	0.3		0.9	
Z_R	Reverse Dynamic Impedance	$I_R = 1 \text{ mA}, f = 120 \text{ Hz},$ $I_{\Delta C} = 0.1 I_R$	LM4040DEM3		0.3	1.1	Ω
	mpodanoo	AC = OII R	LM4040EEM3		0.3	0.9	
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 (5)	ΔT = -40°C to 125°C			0.08%		

⁽⁵⁾ 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.

6.8 Electrical Characteristics: 2.5-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature Grade 'I' (AEC Grade 3)

all other limits T_A = T_I = 25°C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of ±0.1% and +0.2% respectively

	PARAMETER		TEST CONDITIO	NS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	I _R = 100 μA				2.5		V
			LM4040AIM3	$T_A = T_J = 25$ °C			±2.5	
V_R	Davis - Davids		LM4040AIZ LM4040AIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±19	
	Reverse Breakdown Voltage Tolerance ⁽³⁾	$I_R = 100 \mu A$	LM4040BIM3	$T_A = T_J = 25$ °C			±5	mV
			LM4040BIZ LM4040BIM7 LM4040QBIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±21	
	Minimum Operating		$T_A = T_J = 25$ °C			45	60	
I _{RMIN}	Current		$T_A = T_J = T_{MIN}$ to	T _{MAX}			65	μA
	A	I _R = 10 mA				±20		
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage	1 1 2 2	T _A = T _J = 25°C			±15		ppm/°C
ΔVR/ΔI	Temperature Coefficient ⁽³⁾	I _R = 1 mA	$T_A = T_J = T_{MIN}$ to	T _{MAX}			±100	ppm/ C
	Coemcient	I _R = 100 μA				±15		

Typicals are at T_J = 25°C and represent most likely parametric norm.

The overtemperature 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 TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where $\max \Delta T = 65^{\circ} \text{C}$ is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below: C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

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Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x $0.75\% = \pm 19 \text{ mV}.$

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Electrical Characteristics: 2.5-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature Grade 'I' (AEC Grade 3) (continued)

all other limits $T_A = T_J = 25$ °C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of $\pm 0.1\%$ and ±0.2%, respectively.

	PARAMETER		TEST CONDITIONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown	I _{RMIN} ≤ I _R ≤ 1 mA	$T_A = T_J = 25$ °C		0.3	0.8	
$\Delta V_R/\Delta I$	Voltage Change with	IRMIN = IR = I IIIA	$T_A = T_J = T_{MIN}$ to T_{MAX}			1	mV
R	Operating Current Change (4)	1 mA ≤ I _R ≤ 15 mA	$T_A = T_J = 25$ °C		2.5	6	IIIV
	Change	I IIIA S IR S IO IIIA	$T_A = T_J = T_{MIN}$ to T_{MAX}			8	
Z _R	Reverse Dynamic Impedance	$I_R = 1 \text{ mA}, f = 120 \text{ Hz}, \\ I_{AC} = 0.1 I_R$			0.3	0.8	Ω
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 (5)	ΔT = −40°C to 125°C			0.08%		

⁽⁴⁾ 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.

Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.

⁽⁵⁾ 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.



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6.9 Electrical Characteristics: 2.5-V LM4040-N V_R Tolerance Grades 'C', 'D', and 'E'; Temperature Grade 'I' (AEC Grade 3)

all other limits $T_A = T_J = 25$ °C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and ±2%, respectively.

	PARAMETER		TEST CONDITION	IS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	Ι _R = 100 μΑ				2.5		٧
			LM4040CIZ	$T_A = T_J = 25$ °C			±12	
			LM4040CIM3 LM4040CIM7 LM4040QCIM3	$T_A = T_J = T_{MIN} \ to \ T_{MAX}$			±29	
V_R			LM4040DIZ	$T_A = T_J = 25$ °C			±25	
	Reverse Breakdown Voltage Tolerance ⁽³⁾	Ι _R = 100 μΑ	LM4040DIM3 LM4040DIM7 LM4040QDIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±49	mV
			LM4040EIZ	$T_A = T_J = 25$ °C			±50	
			LM4040EIM3 LM4040EIM7 LM4040QEIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±74	
			LM4040CIZ	$T_A = T_J = 25$ °C		45	60	
			LM4040CIM3 LM4040CIM7 LM4040QCIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			65	
	Minimum Operation		LM4040DIZ	$T_A = T_J = 25$ °C		45	65	
I _{RMIN}	Minimum Operating Current		LM4040DIM3 LM4040DIM7 LM4040QDIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			70	μA
			LM4040EIZ	$T_A = T_J = 25$ °C		45	65	
			LM4040EIM3 LM4040EIM7 LM4040QEIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			70	
		I _R = 10 mA				±20		
			LM4040CIZ	$T_A = T_J = 25$ °C		±15		
			LM4040CIM3 LM4040CIM7 LM4040QCIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±100	
	Average Reverse		LM4040DIZ	$T_A = T_J = 25$ °C		±15		
$\Delta V_R / \Delta T$	Breakdown Voltage Temperature Coefficient (3)	I _R = 1 mA	LM4040DIM3 LM4040DIM7 LM4040QDIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	ppm/°C
			LM4040EIZ	$T_A = T_J = 25$ °C		±15		
			LM4040EIM3 LM4040EIM7 LM4040QEIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	
		$I_R = 100 \mu A$				±15		

Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.

Typicals are at T_J = 25°C and represent most likely parametric norm.

The overtemperature 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 TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where $\max \Delta T = 65^{\circ} \text{C}$ is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below: C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x $0.75\% = \pm 19 \text{ mV}.$

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LM4040-N, LM4040-N-Q1

Electrical Characteristics: 2.5-V LM4040-N V_R Tolerance Grades 'C', 'D', and 'E'; Temperature Grade 'I' (AEC Grade 3) (continued)

all other limits T_A = T_J = 25°C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1% and ±2%, respectively.

	PARAMETER		TEST CONDITIONS	3	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
			LM4040CIZ LM4040CIM3 LM4040CIM7 LM4040QCIM3	$T_A = T_J = 25$ °C $T_A = T_J = T_{MIN} \text{ to } T_{MAX}$		0.3	0.8	
			LM4040DIZ	$T_A = T_J = 25$ °C		0.3	1	
		I _{RMIN} ≤ I _R ≤ 1 mA	LM4040DIM3 LM4040DIM7 LM4040QDIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.2	
			LM4040EIZ	$T_A = T_J = 25$ °C		0.3	1	
$\Delta V_R/\Delta I$			LM4040EIM3 LM4040EIM7 LM4040QEIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.2	mV
R	Operating Current Change (4)		LM4040CIZ LM4040CIM3	$T_A = T_J = 25$ °C		2.5	6	IIIV
			LM4040CIM3 LM4040CIM7 LM4040QCIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			8	
			LM4040DIZ LM4040DIM3	$T_A = T_J = 25$ °C		2.5	8	
		1 mA ≤ I _R ≤ 15 mA	LM4040DIM7 LM4040QDIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			10	
			LM4040EIZ LM4040EIM3	$T_A = T_J = 25^{\circ}C$		2.5	8	
			LM4040EIM7 LM4040QEIM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			10	
			LM4040CIZ LM4040CIM3 LM4040CIM7 LM4040QCIM3			0.3	0.9	
Z _R	Reverse Dynamic Impedance	I _R = 1 mA, f = 120 Hz I _{AC} = 0.1 I _R	LM4040DIZ LM4040DIM3 LM4040DIM7 LM4040QDIM3			0.3	1.1	Ω
			LM4040EIZ LM4040EIM3 LM4040EIM7 LM4040QEIM3			0.3	1.1	
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 (5)	ΔT= -40°C to 125°C				0.08%		

⁽⁴⁾ 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.

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Product Folder Links: LM4040-N LM4040-N-Q1

⁽⁵⁾ 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.



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6.10 Electrical Characteristics: 2.5-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'E' (AEC Grade 1)

all other limits $T_A = T_{.I} = 25^{\circ}C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and +2% respectively

1	PARAMETER		TEST CONDITION	s	MIN ⁽¹⁾	TYP(2)	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	I _R = 100 μA				2.5		V
			LM4040CEM3	$T_A = T_J = 25$ °C			±12	
			LM4040QCEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±38	
V_R	Reverse Breakdown	I _R = 100 μA	LM4040DEM3	$T_A = T_J = 25$ °C			±25	mV
	Voltage Tolerance (3)	Ι _R = 100 μΑ	LM4040QDEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±63	IIIV
			LM4040EEM3	$T_A = T_J = 25$ °C			±50	
			LM4040QEEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±88	
			LM4040CEM3	$T_A = T_J = 25$ °C		45	60	
			LM4040QCEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			68	
	Minimum Operating		LM4040DEM3	$T_A = T_J = 25$ °C		45	65	
I _{RMIN}	Current		LM4040QDEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			73	μA
			LM4040EEM3	$T_A = T_J = 25$ °C		45	65	
			LM4040QEEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			73	
	Average Reverse	I _R = 10 mA				±20		
	Breakdown Voltage Temperature Coefficient ⁽³⁾		LM4040CEM3	$T_A = T_J = 25$ °C		±15		
			LM4040QCEM3 $T_A = T_J = T_{MIN}$ to T_{MAX}	$T_A = T_J = T_{MIN}$ to T_{MAX}			±100	
$\Delta V_R/\Delta T$			LM4040DEM3	$T_A = T_J = 25$ °C		±15		ppm/°C
ΔVR/ΔI		I _R = I IIIA	LM4040QDEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	ррпі/ С
			LM4040EEM3	$T_A = T_J = 25$ °C		±15		
			LM4040QEEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	
		I _R = 100 μA				±15		
			LM4040CEM3	$T_A = T_J = 25$ °C		0.3	0.8	
			LM4040QCEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1	
		$I_{RMIN} \le I_R \le 1 \text{ mA}$	LM4040DEM3	$T_A = T_J = 25$ °C		0.3	1	
		I _{RMIN} > I _R > I IIIA	LM4040QDEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.2	
	Reverse Breakdown		LM4040EEM3	$T_A = T_J = 25$ °C		0.3	1	
$\Delta V_R/\Delta I$	Voltage Change		LM4040QEEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.2	mV
R	with Operating Current Change ⁽⁴⁾		LM4040CEM3	$T_A = T_J = 25$ °C		2.5	6	IIIV
	Current Change (7		LM4040QCEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			8	
		1 1 15 1	LM4040DEM3	$T_A = T_J = 25$ °C		2.5	8	
		1 mA ≤ I _R ≤ 15 mA	LM4040QDEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			10	
			LM4040EEM3	$T_A = T_J = 25$ °C		2.5	8	
			LM4040QEEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			10	

- (1) Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- Typicals are at $T_J = 25^{\circ}$ C and represent most likely parametric norm.
- The overtemperature 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 ΔT is the maximum difference in temperature from the reference point of 25°C to T MIN or TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where $max\Delta T = 65$ °C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$ C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below: C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

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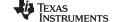
E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x

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.

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LM4040-N, LM4040-N-Q1

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Electrical Characteristics: 2.5-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'E' (AEC Grade 1) (continued)

all other limits $T_A = T_J = 25$ °C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and ±2%, respectively.

	PARAMETER		TEST CONDITIONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
			LM4040CEM3 LM4040QCEM3		0.3	0.9	
Z _R	Reverse Dynamic Impedance	$I_R = 1$ mA, $f = 120$ Hz, $I_{AC} = 0.1$ I_R	LM4040DEM3 LM4040QDEM3		0.3	1.1	Ω
			LM4040EEM3 LM4040QEEM3		0.3	1.1	
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 ⁽⁵⁾	ΔT= -40°C to 125°C			0.08%		

(5) 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.

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LM4040-N, LM4040-N-Q1

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6.11 Electrical Characteristics: 3-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature

all other limits $T_A = T_A = 25$ °C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of $\pm 0.1\%$ and ±0.2%, respectively

	PARAMETER		TEST CONDITIO	NS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	I _R = 100 μA				3		V
			LM4040AIM3	$T_A = T_J = 25$ °C			±3	
V_R	Reverse Breakdown		LM4040AIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±22	
	Voltage Tolerance (3)	I _R = 100 μA	LM4040BIM3	$T_A = T_J = 25$ °C			±6	mV
			LM4040BIZ LM4040BIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±26	
	Minimum Operating		$T_A = T_J = 25$ °C			47	62	μA
I _{RMIN}	Current		$T_A = T_J = T_{MIN}$ to	Гмах			67	μА
	A	I _R = 10 mA				±20		
A\/ /AT	Average Reverse Breakdown Voltage Temperature Coefficient ⁽³⁾	1 1 m A	$T_A = T_J = 25$ °C			±15		ppm/°C
ΔV _R /ΔΙ .		I _R = 1 mA	$T_A = T_J = T_{MIN}$ to	MAX			±100	ppiii/ C
	Coefficient	I _R = 100 μA				±15		
	Reverse Breakdown		$T_A = T_J = 25$ °C			0.6	0.8	
$\Delta V_R/\Delta I$	Voltage Change with	$I_{RMIN} \le I_R \le 1 \text{ mA}$	$T_A = T_J = T_{MIN}$ to	MAX			1.1	mV
R	Operating Current Change (4)	4 4 4 4	$T_A = T_J = 25$ °C			2.7	6	mv
	Change	1 mA ≤ I _R ≤ 15 mA	$T_A = T_J = T_{MIN}$ to	MAX			9	
Z _R	Reverse Dynamic Impedance	I _R = 1 mA, f = 120 Hz, I _{AC} = 0.1 I _R				0.4	0.9	Ω
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 (5)	$\Delta T = -40$ °C to 125°C				0.08%		

- (1) Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- Typicals are at T_J = 25°C and represent most likely parametric norm.
- The overtemperature 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 ΔT 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 overtemperature tolerance for the different grades in the industrial temperature range where max $\Delta T = 65$ °C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100 \text{°C}$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

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E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100 ^{\circ}\text{C}$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x $0.75\% = \pm 19 \text{ mV}.$

- (4) 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.
- 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.

LM4040-N, LM4040-N-Q1



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6.12 Electrical Characteristics: 3-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'I'

all other limits $T_A = T_J = 25$ °C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and ±2%, respectively.

	PARAMETER		TEST CONDITI	ions	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	I _R = 100 μA				3		V
			LM4040CIM3	$T_A = T_J = 25$ °C			±15	
			LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±34	
V_R	Reverse Breakdown	I _R = 100 μA	LM4040DIM3	$T_A = T_J = 25$ °C		1	±30	mV
	Voltage Tolerance (3)	I _R = 100 μA	LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±59	IIIV
			LM4040EIM7	$T_A = T_J = 25$ °C			±60	
			LM4040EIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			3 ±15 ±34 ±30 ±59 ±60 ±89 45 60 65 45 65 70 45 65 70 20 15 ±100 15 ±150	
			LM4040CIM3	$T_A = T_J = 25$ °C		45	60	
			LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN} \ to \ T_{MAX}$			65	
	Minimum Operating		LM4040DIM3	$T_A = T_J = 25$ °C		45	65	μA
I _{RMIN}	Minimum Operating Current		70	μΛ				
			LM4040EIM7	$T_A = T_J = 25$ °C		45	65	
			LM4040EIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			70	
		I _R = 10 mA				±20		
			LM4040CIM3	$T_A = T_J = 25$ °C		±15		
	A		LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±100	
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage	I _R = 1 mA	LM4040DIM3	$T_A = T_J = 25$ °C		±15		ppm/°C
ΔVR/ΔI	Temperature Coefficient ⁽³⁾	IR = I IIIA	LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	ррпі/ С
			LM4040EIM7	$T_A = T_J = 25$ °C		±15		
			LM4040EIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	
		I _R = 100 μA				±15		

- Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- Typicals are at T_J = 25°C and represent most likely parametric norm.
- The overtemperature 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 TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where $max\Delta T = 65^{\circ}C$ is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$ D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100°C$ E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100 \text{°C}$

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Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × $0.75\% = \pm 19 \text{ mV}.$



LM4040-N, LM4040-N-Q1

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Electrical Characteristics: 3-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'I' (continued)

all other limits $T_A = T_J = 25$ °C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and +2% respectively

	PARAMETER		TEST CONDITI	ONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
			LM4040CIM3 LM4040CIZ	$T_A = T_J = 25$ °C		0.4	0.8	
			LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.1	
		I _{RMIN} ≤ I _R ≤ 1 mA	LM4040DIM3 LM4040DIZ	$T_A = T_J = 25$ °C		0.4	1.1	
		RMIN - R - 1	LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.3	
	Reverse Breakdown		LM4040EIM7	$T_A = T_J = 25$ °C		0.4	1.1	
$\Delta V_R/\Delta I$	Voltage Change		LM4040EIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.3	mV
R	with Operating Current Change (4)		LM4040CIM3 LM4040CIZ	$T_A = T_J = 25$ °C		2.7	6	IIIV
	ourient onlinge		LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			9	
		1 mA ≤ I _R ≤ 15 mA	LM4040DIM3	$T_A = T_J = 25$ °C		2.7	8	
		T IIIA 2 IK 2 IS IIIA	LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}		2.7 8 11 2.7 8 11		
			LM4040EIM7	$T_A = T_J = 25$ °C		2.7	8	
			LM4040EIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			11	
			LM4040CIM3 LM4040CIZ LM4040CIM7			0.4	0.9	
Z_R	Reverse Dynamic Impedance	$I_R = 1 \text{ mA}, f = 120 \text{ Hz}$ $I_{AC} = 0.1 I_R$	LM4040DIM3 LM4040DIZ LM4040DIM7			0.4	1.2	Ω
			LM4040EIM7 LM4040EIZ			0.4	1.2	
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 ⁽⁵⁾	$\Delta T = -40$ °C to 125°C				0.08%		

- (4) 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.
- 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.





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6.13 Electrical Characteristics: 3-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'E'

all other limits $T_A = T_J = 25$ °C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and ±2%, respectively.

F	PARAMETER		TEST CONDITI	ONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	Ι _R = 100 μΑ				3		V
			LM4040CEM3	$T_A = T_J = 25$ °C			±15	
			LM4040CEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±45	
V_R	Reverse Breakdown	1 1004	LM4040DEM3	$T_A = T_J = 25$ °C			±30	mV
	Reverse Breakdown Voltage Tolerance ⁽³⁾	I _R = 100 μA	LM4040DEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±75	mv
			LM4040EEM3	$T_A = T_J = 25$ °C			±60	
			LIVI4040EEIVIS	$T_A = T_J = T_{MIN}$ to T_{MAX}			±105	
			LM4040CEM3	$T_A = T_J = 25$ °C		47	62	
			LIVI4040CEIVI3	$T_A = T_J = T_{MIN}$ to T_{MAX}			70	
	Minimum Operating		LM4040DEM0	$T_A = T_J = 25$ °C		47	67	
I _{RMIN}	Current		LM4040DEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			75	μΑ
			1.0440.4055040	$T_A = T_J = 25$ °C		47	67	
			LM4040EEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			75	
		I _R = 10 mA				±20		
			LM40400EM0	$T_A = T_J = 25$ °C		±15		
		LM4040CEM3 $T_A = T_J = T_{MIN} \text{ to } T_{MAX}$ $T_A = T_J = T_{MIN} \text{ to } T_{MAX}$			±100			
A)/ /AT	Average Reverse Breakdown Voltage		$T_A = T_J = 25$ °C		±15		ppm/°C	
$\Delta V_R/\Delta T$	Temperature Coefficient (3)	I _R = 1 mA	LM4040DEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	ррпі/ С
	Coefficient		LM4040EEM3	$T_A = T_J = 25$ °C		±15		
			LIVI4040EEIVIS	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	
		I _R = 100 μA				±15		
			LM40400EM0	$T_A = T_J = 25$ °C		0.4	0.8	
			LM4040CEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.1	
			LM4040DEM2	$T_A = T_J = 25$ °C		0.4	1.1	
		$I_{RMIN} \le I_R \le 1 \text{ mA}$	LM4040DEM3	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.3	
	Reverse Breakdown		LM4040EEM3	$T_A = T_J = 25$ °C		0.4	1.1	
۸۱/ /۸۱	Voltage Change		LIVI4040EEIVIS	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.3	mV
$\Delta V_R / \Delta I_R$	with Operating Current Change (4)		LM4040CEM3	$T_A = T_J = 25$ °C		2.7	6.0	IIIV
	Current Change "		LIVI4U4UCEIVI3	$T_A = T_J = T_{MIN}$ to T_{MAX}			9	
		1 - 0 < 1 < 15 - 0 0	LM4040DEM3	$T_A = T_J = 25$ °C		2.7	8	
		1 mA ≤ I _R ≤ 15 mA	LIVI4U4UDEIVI3	$T_A = T_J = T_{MIN}$ to T_{MAX}			11.0	
			LM4040EEM3	$T_A = T_J = 25$ °C		2.7	8	
			LIVI4U4UEEIVI3	$T_A = T_J = T_{MIN}$ to T_{MAX}			11.0	

- (1) Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- Typicals are at T_J = 25°C and represent most likely parametric norm.
- The (overtemperature) limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance $\pm I(\Delta V_R/\Delta T)(max\Delta T)(V_R)I$. Where, $\Delta V_R/\Delta T$ is the V_R temperature coefficient, max ΔT is the maximum difference in temperature from the reference point of 25°C to T MIN or TMAX, and V_R is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where max $\Delta T = 65$ °C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below: C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100°C$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x

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.

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LM4040-N, LM4040-N-Q1

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Electrical Characteristics: 3-V LM4040-N V_R Tolerance Grades 'C', 'D', And 'E'; Temperature Grade 'E' (continued)

all other limits $T_A = T_J = 25^{\circ}$ C. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1\%$ and ±2%, respectively.

F	PARAMETER		TEST CONDITIONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
		I _R = 1 mA, f = 120	LM4040CEM3		0.4	0.9	
Z_R	Impodence	Hz,	LM4040DEM3	0.4 1.2	1.2	Ω	
		I _{AC} = 0.1 I _R	LM4040EEM3		0.4	1.2	
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 ⁽⁵⁾	$\Delta T = -40$ °C to 125°C			0.08%		

(5) 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.

6.14 Electrical Characteristics: 4.1-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature

all other limits T_A = T_I = 25°C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of ±0.1% and +0.2% respectively

	PARAMETER		TEST CONDITION	IS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	Ι _R = 100 μΑ				4.096		V
			LM4040AIM3	$T_A = T_J = 25$ °C			±4.1	
V_R	Reverse Breakdown		LM4040AIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}		±31		
	Voltage Tolerance (3)	I _R = 100 μA	LM4040BIM3	$T_A = T_J = 25$ °C			±8.2	mV
			LM4040BIZ LM4040BIM7 $T_A = T_J = T_{MIN}$ to T	$T_A = T_J = T_{MIN}$ to T_{MAX}			±35	
	Minimum Operating		$T_A = T_J = 25$ °C			50	68	
I _{RMIN}	Current		$T_A = T_J = T_{MIN}$ to T_{MAX}				73	μA
	Average Reverse	I _R = 10 mA				±30		
$\Delta V_R/\Delta T$	Breakdown Voltage	1 1 m A	$T_A = T_J = 25$ °C			±20		ppm/°C
ΔVR/ΔI	Temperature Coefficient ⁽³⁾	I _R = 1 mA	$T_A = T_J = T_{MIN}$ to T	MAX			±100	ppiii/ C
	Coefficient	$I_R = 100 \mu A$				±20		
	Reverse Breakdown	$I_{RMIN} \le I_R \le 1 \text{ mA}$	$T_A = T_J = 25^{\circ}C$			0.5	0.9	
$\Delta V_R/\Delta I$	Voltage Change with	IRMIN S IR S I IIIA	$T_A = T_J = T_{MIN}$ to T	MAX			1.2	mV
R	Operating Current Change (4)	Operating Current	$T_A = T_J = 25^{\circ}C$			3	7	IIIV
	Griange ·	1 mA ≤ I _R ≤ 15 mA	$T_A = T_J = T_{MIN}$ to T	MAX			10	

(1) Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.

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

The (overtemperature) 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 ΔT is the maximum difference in temperature from the reference point of 25°C to T MIN or TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where max $\Delta T = 65$ °C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below: C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100 \text{°C}$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100°C$ E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

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Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x

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.

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Electrical Characteristics: 4.1-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature Grade 'l' (continued)

all other limits $T_A = T_J = 25$ °C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of $\pm 0.1\%$ and ±0.2%, respectively.

	PARAMETER		TEST CONDITIONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
Z _R	Reverse Dynamic Impedance	$I_{R}=1 \text{ mA, f}=120 \text{ Hz,} \\ I_{AC}=0.1 I_{R}$			0.5	1	Ω
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 (5)	$\Delta T = -40$ °C to 125°C			0.08%		

(5) 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.

6.15 Electrical Characteristics: 4.1-V LM4040-N V_R Tolerance Grades 'C' and 'D'; Temperature Grade 'I'

all other limits T_A = T₁ = 25°C. The grades C and D designate initial Reverse Breakdown Voltage tolerances of ±0.5% and +1% recoertively

, , ,	respectively.				(1)	(2)	(4)	
	PARAMETER		TEST CONDITIO	DNS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	I _R = 100 μA				4.096		V
			LM4040CIM3	$T_A = T_J = 25$ °C			±20	
V_R	Reverse Breakdown	Ι _R = 100 μΑ	LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}	±47	±47	mV	
	Voltage Tolerance (3)	Ι _R = 100 μΑ	LM4040DIM3	$T_A = T_J = 25$ °C			±41	IIIV
			LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±81	
			LM4040CIM3	$T_A = T_J = 25$ °C		50	68	
	Minimum Operating		LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			73	
I _{RMIN}	Current	LN	LM4040DIM3	$T_A = T_J = 25$ °C		50	73	μΑ
			LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			78	
		I _R = 10 mA				±30		
			LM4040CIM3	$T_A = T_J = 25$ °C		±20		
ΔV_R /	Average Reverse Breakdown Voltage	I _R = 1 mA	LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±100	nnm/9C
ΔΤ	Temperature Coefficient ⁽³⁾	I _R = I IIIA	LM4040DIM3	$T_A = T_J = 25$ °C		±20		ppm/°C
	Coefficient		LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	
		$I_R = 100 \mu A$				±20		

Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.

Typicals are at T_J = 25°C and represent most likely parametric norm.

The (overtemperature) 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 TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where $\max \Delta T = 65^{\circ} \text{C}$ is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$ D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100 \text{°C}$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = +19 mV



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Electrical Characteristics: 4.1-V LM4040-N V_R Tolerance Grades 'C' and 'D'; Temperature Grade 'I' (continued)

all other limits $T_A = T_J = 25$ °C. The grades C and D designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$ and $\pm 1\%$, respectively.

	PARAMETER		TEST CONDITIO	ONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
			LM4040CIM3	$T_A = T_J = 25$ °C		0.5	0.9	
		I _{RMIN} ≤ I _R ≤ 1 mA	LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.2	
		I _{RMIN} > I _R > I IIIA	LM4040DIM3	$T_A = T_J = 25$ °C		0.5	1.2	
ΔV_R	Reverse Breakdown Voltage Change with		LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.5	mV
ΔI_R	Operating Current Change (4)		LM4040CIM3	$T_A = T_J = 25$ °C		3	7	IIIV
	Change	4 4 4 4 4	LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			10	
		1 mA ≤ I _R ≤ 15 mA	LM4040DIM3	$T_A = T_J = 25$ °C		3	9	
			LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			13	
Z _R	Reverse Dynamic	I _R = 1 mA, f = 120 Hz,	LM4040CIM3 LM4040CIZ LM4040CIM7	•		0.5	1	Ω
∠ _R	Impedance	I _{AC} = 0.1 I _R	LM4040DIM3 LM4040DIZ LM4040DIM7			0.5	1.3	Ω
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 (5)	$\Delta T = -40$ °C to 125°C				0.08%		

- (4) 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.
- (5) 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.

6.16 Electrical Characteristics: 5-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature Grade 'I'

all other limits $T_A = T_J = 25$ °C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of $\pm 0.1\%$ and $\pm 0.2\%$, respectively.

	PARAMETER		TEST CONDITIO	NS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	Ι _R = 100 μΑ				5		V
			LM4040AIM3	$T_A = T_J = 25$ °C			±5	
V_R	Reverse Breakdown		LM4040AIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±38	
	Voltage Tolerance (3)	ce ⁽³⁾ I _R = 100 μA Li	LM4040BIM3	$T_A = T_J = 25$ °C			±10	mV
		LM4040BI LM4040BI		$T_A = T_J = T_{MIN}$ to T_{MAX}			±43	

- Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- Typicals are at T_J = 25°C and represent most likely parametric norm.
- 3) The (overtemperature) limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±{(ΔV_R/ΔT)(maxΔT)(V_R)}. Where, ΔV_R/ΔT is the V_R temperature coefficient, maxΔT 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 overtemperature tolerance for the different grades in the industrial temperature range where maxΔT = 65°C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65°C$

B-grade: ±0.85% = ±0.2% ±100 ppm/°C × 65°C

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below: C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100$ ppm/°C × ± 100 ppm/°C

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100 \text{°C}$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ± 2.5 V x $0.75\% = \pm 19$ mV.

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Electrical Characteristics: 5-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature Grade 'I' (continued)

all other limits $T_A = T_J = 25$ °C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of $\pm 0.1\%$ and $\pm 0.2\%$, respectively.

	PARAMETER		TEST CONDITIONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Minimum Operating		$T_A = T_J = 25$ °C		54	74	μA
I _{RMIN}	Current		$T_A = T_J = T_{MIN}$ to T_{MAX}		80		
	Average Deverse	I _R = 10 mA			±30		
$\Delta V_R/\Delta$	Average Reverse Breakdown Voltage	I _R = 1 mA	$T_A = T_J = 25$ °C		±20		ppm/°C
Т	Temperature Coefficient ⁽³⁾	IR = I IIIA	$T_A = T_J = T_{MIN}$ to T_{MAX}			±100	ррпі/ С
	Coefficient	$I_R = 100 \mu A$			±20		
	Reverse Breakdown		$T_A = T_J = 25$ °C		0.5	±100 1 1.4 8 12	
	Voltage Change with	$I_{RMIN} \le I_R \le 1 \text{ mA}$	$T_A = T_J = T_{MIN}$ to T_{MAX}				\/
IR	Operating Current Change (4)	1 m A < 1 < 15 m A	$T_A = T_J = 25$ °C		3.5		mV
	Change	1 mA ≤ I _R ≤ 15 mA	$T_A = T_J = T_{MIN}$ to T_{MAX}			12	
Z_R	Reverse Dynamic Impedance	I _R = 1 mA, f = 120 Hz, I _{AC} = 0.1 I _R			0.5	1.1	Ω
e _N	Wideband Noise	$I_R = 100 \mu A$ 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 (5)	ΔT = −40°C to 125°C			0.08%		

- (4) 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.
- (5) 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.

6.17 Electrical Characteristics: 5-V LM4040-N V_R Tolerance Grades 'C' And 'D'; Temperature Grade 'I'

all other limits $T_A = T_J = 25$ °C. The grades C and D designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$ and $\pm 1\%$. respectively.

	PARAMETER		TEST CONDITIO	NS	MIN ⁽¹⁾ TYP ⁽²⁾ MAX ⁽¹⁾			UNIT
	Reverse Breakdown Voltage	Ι _R = 100 μΑ				5		V
			LM4040CIM3	$T_A = T_J = 25$ °C			±25	
V_{R}	Reverse Breakdown	1 1004	LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±58	mV
	Voltage Tolerance (3)	I _R = 100 μA	LM4040DIM3	$T_A = T_J = 25$ °C	±50	mv		
			LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±99	

- Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- (2) Typicals are at T_J = 25°C and represent most likely parametric norm.
- The (overtemperature) limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[(ΔV_R/ΔΤ)(maxΔΤ)(V_R)]. Where, ΔV_R/ΔΤ is the V_R temperature coefficient, maxΔT 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 overtemperature tolerance for the different grades in the industrial temperature range where maxΔT = 65°C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65 ^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$ D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100°C$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x 0.75% = ±1.9 mV.



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Electrical Characteristics: 5-V LM4040-N V_R Tolerance Grades 'C' And 'D'; Temperature Grade 'I' (continued)

all other limits $T_A = T_J = 25$ °C. The grades C and D designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$ and $\pm 1\%$, respectively.

	PARAMETER		TEST CONDITIO	NS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT	
			LM4040CIM3	$T_A = T_J = 25^{\circ}C$		54	74		
	Minimum Operating		LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			80		
I _{RMIN}	Current		LM4040DIM3	$T_A = T_J = 25$ °C		54	79	μΑ	
			LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			85		
		I _R = 10 mA				±30			
			LM4040CIM3	$T_A = T_J = 25$ °C		±20			
ΔV _R /Δ	Average Reverse Breakdown Voltage	1 4 55 4	LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±100	100	
Ť	Temperature Coefficient ⁽³⁾	I _R = 1 mA	LM4040DIM3	$T_A = T_J = 25$ °C		±20		ppm/°C	
	Coefficient		LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150		
		I _R = 100 μA				±20			
			LM4040CIM3	$T_A = T_J = 25$ °C		0.5	1		
		I _{RMIN} ≤ I _R ≤ 1 mA	$I_{RMIN} \le I_R \le 1 \text{ mA}$	LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.4	
				LM4040DIM3	$T_A = T_J = 25$ °C		0.5	1.3	
ΔV _R /Δ	Reverse Breakdown Voltage Change with		LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.8	mV	
IR	Operating Current Change (4)		LM4040CIM3	$T_A = T_J = 25$ °C		3.5	8	IIIV	
	Change		LM4040CIZ LM4040CIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			12		
		1 mA ≤ I _R ≤ 15 mA	LM4040DIM3	$T_A = T_J = 25$ °C		3.5	10		
			LM4040DIZ LM4040DIM7	$T_A = T_J = T_{MIN}$ to T_{MAX}			15		
Z _R	Reverse Dynamic	I _R = 1 mA, f = 120 Hz,	$T_A = T_J = 25$ °C			0.5	1.1	Ω	
Z-R	Impedance	$I_{AC} = 0.1 I_{R}$	$T_A = T_J = T_{MIN}$ to	T _{MAX}			1.5	12	
e_{N}	Wideband Noise	$I_R = 100 \mu A$ 10 Hz \leq f \leq 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 (5)	$\Delta T = -40$ °C to 125°C				0.08%			

⁽⁴⁾ 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.





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6.18 Electrical Characteristics: 5-V LM4040-N V_R Tolerance Grades 'C' And 'D'; Temperature Grade 'E'

all other limits $T_A = T_J = 25$ °C. The grades C and D designate initial Reverse Breakdown Voltage tolerances of ±0.5% and ±1%, respectively.

	PARAMETER		TEST CONDITION	IS	MIN ⁽¹⁾	TYP	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	Ι _R = 100 μΑ				5		V
			LM4040CEM3	$T_A = T_J = 25$ °C			±25	
V_R	Reverse Breakdown	I _R = 100 μA	LIVI4040CEIVI3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±75	mV
	Voltage Tolerance (2)	Ι _R = 100 μΑ	LM4040DEM3	$T_A = T_J = 25$ °C			±50	IIIV
			LIVI4040DEIVI3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±125	
			LM4040CEM3	$T_A = T_J = 25$ °C		54	74	
l	Minimum Operating		EW4040CEWS	$T_A = T_J = T_{MIN}$ to T_{MAX}			83	μА
RMIN	Current		LM4040DEM3	$T_A = T_J = 25$ °C		54	79	μΛ
			LIVI4040DLIVIS	$T_A = T_J = T_{MIN}$ to T_{MAX}			88	
		I _R = 10 mA				±30		
	Average Reverse		LM4040CEM3	$T_A = T_J = 25$ °C		±20		
ΔV _R /	Breakdown Voltage	I _R = 1 mA	LIVI4040CEIVI3	$T_A = T_J = T_{MIN}$ to T_{MAX}			±20 ±150	nnm/ºi
	Temperature Coefficient ⁽²⁾	IR = I IIIA	LM4040DEM3	$T_A = T_J = 25$ °C		±20		ppiii/ v
	Cocmoloni		EW4040DEW3	$T_A = T_J = T_{MIN}$ to T_{MAX}				
		I _R = 100 μA				±20		
			LM4040CEM3	$T_A = T_J = 25$ °C		0.5	1	
		$I_{RMIN} \le I_R \le 1 \text{ mA}$	ENITOTOCENIO	$T_A = T_J = T_{MIN}$ to T_{MAX}			±75 ±50 ±125 74 83 79 88 ±100	
	Reverse Breakdown	IRMIN - IR - I III/	LM4040DEM3	$T_A = T_J = 25$ °C		0.5		
ΔV _R /	Voltage Change with		EIVITOTOBEIVIO	$T_A = T_J = T_{MIN}$ to T_{MAX}			1.8	±150 1 1.4 1 1.8 8 12
ΔI_R	Operating Current Change (3)		LM4040CEM3	$T_A = T_J = 25$ °C		3.5	8	1114
	Onlingo	1 mA ≤ I _R ≤ 15 mA	EW4040CEWS	$T_A = T_J = T_{MIN}$ to T_{MAX}			12	
		T IIIA = IR = 15 IIIA	LM4040DEM3	$T_A = T_J = 25$ °C		3.5	8	
			EW4040DEW3	$T_A = T_J = T_{MIN}$ to T_{MAX}			15	
Z_R	Reverse Dynamic Impedance	$I_R = 1 \text{ mA}, f = 120 \text{ Hz},$ $I_{AC} = 0.1 I_R$				0.5	1.1	Ω
e _N	Wideband Noise	$I_R = 100 \mu A$ 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
/ _{HYST}	Thermal Hysteresis (4)	ΔT = -40°C to 125°C				0.08%		

- Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- 2) The (overtemperature) limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[(ΔN_R/ΔT)(maxΔT)(N_R)]. Where, ΔN_R/ΔT is the V_R temperature coefficient, maxΔT 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 overtemperature tolerance for the different grades in the industrial temperature range where maxΔT = 65°C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150$ ppm/°C × 65°C

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

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

- (3) 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.
- (4) 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.

⁽⁵⁾ 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.



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6.19 Electrical Characteristics: 8.2-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature

all other limits $T_A = T_A = 25$ °C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of $\pm 0.1\%$ and IO 20/ reapportively

±0.2 /0,	respectively.							
	PARAMETER		TEST CONDITIO	NS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	I _R = 150 μA				8.192		V
			LM4040AIM3	$T_A = T_J = 25$ °C			±8.2	
V _R	Reverse Breakdown	I _R = 150 μA	LM4040AIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±61	mV
	Voltage Tolerance (3)	I _R = 150 μA	LM4040BIM3	$T_A = T_J = 25$ °C			±16	mv
			LM4040BIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±70	
	Minimum Operating		$T_A = T_J = 25$ °C			67	91	μA
I _{RMIN}	Current		$T_A = T_J = T_{MIN} t$	o T _{MAX}			95	μА
	A	I _R = 10 mA				±40		
A)/ /AT	Average Reverse Breakdown Voltage	1 4 4	$T_A = T_J = 25$ °C			±20		
Δν _R /Δ1	V _R /ΔT Temperature Coefficient ⁽³⁾	I _R = 1 mA	$T_A = T_J = T_{MIN} t$	o T _{MAX}			±100	ppm/°C
	Coefficient	I _R = 150 μA				±20		
	Reverse Breakdown		$T_A = T_J = 25$ °C			0.6	1.3	
$\Delta V_R/\Delta I$	Voltage Change with	$I_{RMIN} \le I_R \le 1 \text{ mA}$	$T_A = T_J = T_{MIN} t$	o T _{MAX}			2.5	mV
R	Operating Current	4 4 4 4 4 5 4	$T_A = T_J = 25$ °C			7	10	mv
	Change (4)	1 mA ≤ I _R ≤ 15 mA	$T_A = T_J = T_{MIN} t$	o T _{MAX}			18	
Z _R	Reverse Dynamic Impedance	I _R = 1 mA, f = 120 Hz, I _{AC} = 0.1 I _R				0.6	1.5	Ω
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 (5)	ΔT = -40°C to 125°C				0.08%		

- Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- Typicals are at $T_J = 25^{\circ}$ C and represent most likely parametric norm.
- The (overtemperature) 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 TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where max $\Delta T = 65$ °C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$ B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100 \text{°C}$ D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100°C$

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E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

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

- (4) 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.
- 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.

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6.20 Electrical Characteristics: 8.2-V Lm4040-N V_R Tolerance Grades 'C' And 'D'; Temperature Grade 'l'

all other limits $T_A = T_L = 25$ °C. The grades C and D designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$ and ±1%, respectively.

	PARAMETER		TEST CONDITI	ONS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT
	Reverse Breakdown Voltage	I _R = 150 μA				8.192		V
			LM4040CIM3	$T_A = T_J = 25$ °C			±41	
V_R	Reverse Breakdown	4504	LM4040CIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±94	mV
	Voltage Tolerance (3)	I _R = 150 μA	LM4040DIM3	$T_A = T_J = 25$ °C			±82	mv
			LM4040DIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±162	
			LM4040CIM3	$T_A = T_J = 25$ °C		67	91	
I _{RMIN}	Minimum Operating		LM4040CIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			95	μA
RMIN	Current		LM4040DIM3	$T_A = T_J = 25$ °C		67	96	μл
			LM4040DIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			100	
		$I_R = 10 \text{ mA}$				±40		
	Average Reverse		LM4040CIM3	$T_A = T_J = 25$ °C		±20		
V _R /ΔT	Breakdown Voltage	I _R = 1 mA	LM4040CIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}		±20	±100	ppm/°C
v R/ДI	Temperature Coefficient ⁽³⁾	IR - I IIIA	LM4040DIM3	$T_A = T_J = 25$ °C				
	Cocmoient		LM4040DIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±150	
		$I_R = 150 \mu A$				±20		
			LM4040CIM3	$T_A = T_J = 25$ °C		0.6	1.3	
		$I_{RMIN} \le I_R \le 1 \text{ mA}$	LM4040CIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			2.5	
	Reverse Breakdown	IRMIN = IR = I IIIA	LM4040DIM3	$T_A = T_J = 25$ °C		0.6	1.7	
ΔV _R /ΔI	Voltage Change with		LM4040DIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			±94 ±82 ±162 91 95 96 100 ±100 ±150 1.3 2.5	
R	Operating Current Change (4)		LM4040CIM3	$T_A = T_J = 25$ °C		7	10	1110
	Change	1 mA ≤ I _R ≤ 15 mA	LM4040CIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			18	
		T IIIA 2 IR 2 IS IIIA	LM4040DIM3	$T_A = T_J = 25$ °C		7	15	
			LM4040DIZ	$T_A = T_J = T_{MIN}$ to T_{MAX}			24	
Z_R	Reverse Dynamic	I _R = 1 mA, f = 120 Hz,	LM4040CIM3 LM4040CIZ			0.6	1.5	0
∠ R	Impedance	I _{AC} = 0.1 I _R	LM4040DIM3 LM4040DIZ			0.6	1.9	32
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 (5)	ΔT = −40°C to 125°C				0.08%		

- Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL
 - Typicals are at $T_1 = 25^{\circ}$ C and represent most likely parametric norm.
- The (overtemperature) 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 ΔT is the maximum difference in temperature from the reference point of 25°C to T MIN or TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where $\max \Delta T = 65^{\circ}C$ is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100°C$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100°C$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100 ^{\circ}\text{C}$

Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x $0.75\% = \pm 19 \text{ mV}.$

- 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.
- 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.

Product Folder Links: LM4040-N LM4040-N-Q1

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6.21 Electrical Characteristics: 10-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature

all other limits $T_A = T_A = 25$ °C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of $\pm 0.1\%$ and ±0.2%, respectively

PARAMETER		TEST CONDITIONS			MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT	
V _R	Reverse Breakdown Voltage	Ι _R = 150 μΑ				10		V	
	Reverse Breakdown Voltage Tolerance ⁽³⁾	I _R = 150 μA	LM4040AIM3 LM4040AIZ	$T_A = T_J = 25$ °C			±10	mV	
				$T_A = T_J = T_{MIN}$ to T_{MAX}			±75		
			LM4040BIM3 LM4040BIZ	$T_A = T_J = 25$ °C			±20		
				$T_A = T_J = T_{MIN}$ to T_{MAX}			±85		
I _{RMIN}	Minimum Operating Current		$T_A = T_J = 25$ °C			75	100	μΑ	
			$T_A = T_J = T_{MIN}$ to T_{MAX}				103		
ΔV _R /ΔΤ	Average Reverse Breakdown Voltage Temperature Coefficient ⁽³⁾	$I_R = 10 \text{ mA}$				±40		·	
		I _R = 1 mA	$T_A = T_J = 25$ °C			±20		ppm/°C	
			$T_A = T_J = T_{MIN}$ to T_{MAX}				±100		
		I _R = 150 μA				±20			
	Reverse Breakdown Voltage Change with Operating Current Change (4)	I _{RMIN} ≤ I _R ≤ 1 mA	$T_A = T_J = 25$ °C			0.8	1.5	mV	
ΔV _R /ΔI R			$T_A = T_J = T_{MIN}$ to T_{MAX}				3.5		
		1 mA ≤ I _R ≤ 15 mA	$T_A = T_J = 25$ °C			8	12		
			$T_A = T_J = T_{MIN}$ to T_{MAX}				23		
Z_R	Reverse Dynamic Impedance	$I_R = 1 \text{ mA}, f = 120 \text{ Hz}, I_{AC} = 0.1 I_R$				0.7	1.7	Ω	
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 (5)	$\Delta T = -40$ °C to 125°C		·		0.08%			

- Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
- Typicals are at $T_J = 25^{\circ}$ C and represent most likely parametric norm.
- The (overtemperature) 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 TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where max $\Delta T = 65$ °C is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$ B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100 \text{°C}$ D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100°C$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100^{\circ}\text{C}$

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

- (4) 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.
- 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.

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6.22 Electrical Characteristics: 10-V LM4040-N V_R Tolerance Grades 'C' And 'D'; Temperature Grade 'l'

all other limits $T_A = T_L = 25$ °C. The grades C and D designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$ and ±1%, respectively.

	PARAMETER		TEST CONDITIO	NS	MIN ⁽¹⁾	TYP ⁽²⁾	MAX ⁽¹⁾	UNIT	
	Reverse Breakdown Voltage	I _R = 150 μA				10		V	
V_R	Reverse Breakdown Voltage Tolerance ⁽³⁾	I _R = 150 μA	LM4040CIM3 LM4040CIZ	$T_A = T_J = 25$ °C			±50	mV	
				$T_A = T_J = T_{MIN}$ to T_{MAX}			±115		
			LM4040DIM3 LM4040DIZ	$T_A = T_J = 25$ °C			±100		
				$T_A = T_J = T_{MIN}$ to T_{MAX}			±198		
	Minimum Operating Current		LM4040CIM3 LM4040CIZ	$T_A = T_J = 25$ °C		75	100	μА	
I				$T_A = T_J = T_{MIN}$ to T_{MAX}			103		
I _{RMIN}			LM4040DIM3 LM4040DIZ	$T_A = T_J = 25$ °C		75	110		
				$T_A = T_J = T_{MIN}$ to T_{MAX}			113		
		I _R = 10 mA				±40		ppm/°C	
	Average Reverse Breakdown Voltage Temperature Coefficient ⁽³⁾	I _R = 1 mA	LM4040CIM3 LM4040CIZ	$T_A = T_J = 25$ °C		±20			
$\Delta V_R/\Delta T$				$T_A = T_J = T_{MIN}$ to T_{MAX}			±100		
ΔV _R /Δ1			LM4040DIM3 LM4040DIZ	$T_A = T_J = 25$ °C		±20			
				$T_A = T_J = T_{MIN}$ to T_{MAX}			±150		
		I _R = 150 μA				±20			
	Reverse Breakdown Voltage Change with Operating Current Change (4)	$I_{RMIN} \le I_R \le 1 \text{ mA}$	LM4040CIM3 LM4040CIZ	$T_A = T_J = 25$ °C		0.8	1.5	mV	
				$T_A = T_J = T_{MIN}$ to T_{MAX}			3.5		
			LM4040DIM3 LM4040DIZ	$T_A = T_J = 25$ °C		0.8	2		
ΔV _R /ΔΙ				$T_A = T_J = T_{MIN}$ to T_{MAX}			4		
R		1 mA ≤ I _R ≤ 15 mA	LM4040CIM3 LM4040CIZ	$T_A = T_J = 25$ °C		8	12		
				$T_A = T_J = T_{MIN}$ to T_{MAX}			23		
			LM4040DIM3 LM4040DIZ	$T_A = T_J = 25$ °C		8	18		
				$T_A = T_J = T_{MIN}$ to T_{MAX}			29		
Z _R	Reverse Dynamic Impedance	I _R = 1 mA, f = 120 Hz, I _{AC} = 0.1 I _R	LM4040CIM3 LM4040CIZ			0.7	1.7	Ω	
			LM4040DIM3 LM4040DIZ				2.3		
e _N	Wideband Noise	$I_R = 150 \mu A$ 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 (5)	ΔT = −40°C to 125°C				0.08%			

- Limits are 100% production tested at 25°C. Limits over temperature are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
 - Typicals are at $T_1 = 25^{\circ}$ C and represent most likely parametric norm.
- The (overtemperature) 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 ΔT is the maximum difference in temperature from the reference point of 25°C to T MIN or TMAX, and VR is the reverse breakdown voltage. The total overtemperature tolerance for the different grades in the industrial temperature range where $\max \Delta T = 65^{\circ}C$ is shown below:

A-grade: $\pm 0.75\% = \pm 0.1\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

B-grade: $\pm 0.85\% = \pm 0.2\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65^{\circ}\text{C}$

D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

E-grade: $\pm 2.98\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 65^{\circ}\text{C}$

The total overtemperature tolerance for the different grades in the extended temperature range where max $\Delta T = 100$ °C is shown below:

C-grade: $\pm 1.5\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 100^{\circ}\text{C}$

D-grade: $\pm 2.5\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 100°C$

E-grade: $\pm 3.5\% = \pm 2.0\% \pm 150 \text{ ppm/°C} \times 100 ^{\circ}\text{C}$

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Therefore, as an example, the A-grade 2.5-V LM4040-N has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V x $0.75\% = \pm 19 \text{ mV}.$

- 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.
- 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.

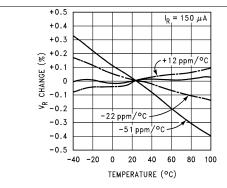
LM4040-N, LM4040-N-Q1

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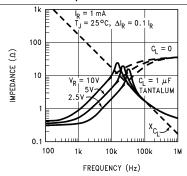
6.23 Typical Characteristics



IMPEDANCE (Ω) TANTALUM 100 10k 100k FREQUENCY (Hz)

Figure 1. Temperature Drift For Different Average Temperature Coefficient

Figure 2. Output Impedance vs Frequency



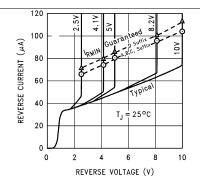


Figure 3. Output Impedance vs Frequency

Figure 4. Reverse Characteristics And Minimum Operating Current

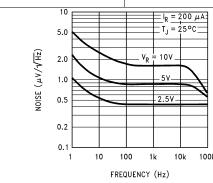


Figure 5. Noise Voltage vs Frequency

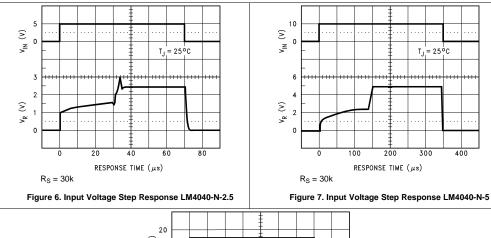
Product Folder Links: LM4040-N LM4040-N-Q1

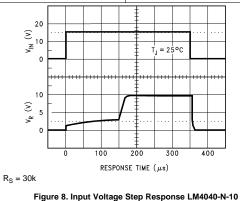
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6.23.1 Start-Up Characteristics





7 Parameter Measurement Information

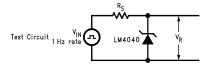


Figure 9. Test Circuit

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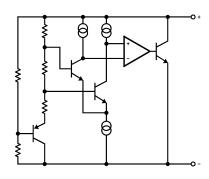
8 Detailed Description

8.1 Overview

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The LM4040 device is a precision micropower shunt voltage reference available in 7 different fixed-output voltage options and three different packages to meet small footprint requirements. The part is also available in five different tolerance grades.

8.2 Functional Block Diagram



8.3 Feature Description

The LM4040 device is effectively a precision Zener diode. The part requires a small guiescent current for regulation, and regulates the output voltage by shunting more or less current to ground, depending on input voltage and load. The only external component requirement is a resistor between the cathode and the input voltage to set the input current. An external capacitor can be used on the input or output, but is not required.

8.4 Device Functional Modes

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The LM4040 device is a fixed output voltage part, where the feedback is internal. Therefore, the part can only operate is a closed loop mode and the output voltage cannot be adjusted. The output voltage will remain in regulation as long as I_R is between I_{RMIN}, see Electrical Characteristics: 2-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature Grade 'I', and I_{RMAX}, 15 mA. Proper selection of the external resistor for input voltage range and load current range will ensure these conditions are met.

LM4040-N. LM4040-N-Q1

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9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

The LM4040-N is a precision micropower curvature-corrected bandgap shunt voltage reference. For space critical applications, the LM4040-N is available in the sub-miniature SOT-23 and SC70 surface-mount package. The LM4040-N 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-N remains stable. Reducing design effort is the availability of several fixed reverse breakdown voltages: 2.048 V, 2.5 V, 3 V, 4.096 V, 5 V, 8.192 V, and 10 V. The minimum operating current increases from 60 µÅ for the LM4040-N-2.048 and LM4040-N-2.5 to 100 µA for the 10-V LM4040-N. All versions have a maximum operating current of 15 mA.

LM4040-Ns 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.

LM4040-Ns 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 4.096-V version allows single 5-V 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 10 V or greater, the 8.192-V 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_{OLIT} 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 10), an external series resistor (R_S) is connected between the supply voltage and the LM4040-N. Rs determines the current that flows through the load (I_I) and the LM4040-N (I_O). Since load current and supply voltage may vary, R_S should be small enough to supply at least the minimum acceptable Io to the LM4040-N 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_I is at its minimum, R_S should be large enough so that the current flowing through the LM4040-N is less than 15 mA.

 R_S is determined by the supply voltage, (V_S) , the load and operating current, $(I_L$ and $I_O)$, and the LM4040-N's reverse breakdown voltage, V_R.

$$R_S = \frac{V_S - V_R}{I_L + I_Q} \tag{1}$$

9.2 Typical Applications

9.2.1 Shunt Regulator

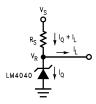


Figure 10. Shunt Regulator Schematic



LM4040-N, LM4040-N-Q1

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Typical Applications (continued)

9.2.1.1 Design Requirements

 $V_{IN} > V_{OUT}$

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Select Rs such that:

 $I_{RMIN} < I_{R} < I_{RMAX}$ where $I_{RMAX} = 15$ mA

See *Electrical Characteristics: 2-V LM4040-N V_R Tolerance Grades 'A' And 'B'; Temperature Grade 'I'* for minimum operating current for each voltage option and grade.

9.2.1.2 Detailed Design Procedure

The resistor R_S must be selected such that current IR will remain in the operational region of the part for the entire V_{IN} range and load current range. The two extremes to consider are V_{IN} at its minimum, and the load at its maximum, where R_S must be small enough for I_R to remain above I_{RMIN} . The other extreme is V_{IN} at its maximum, and the load at its minimum, where R_S must be large enough to maintain $I_R < I_{RMAX}$. For most designs, 0.1 mA $\leq I_R \leq 1$ mA is a good starting point.

Use Equation 2 and Equation 3 to set R_S between $R_{S\ MIN}$ and $R_{S\ MAX}$.

$$R_{S_MIN} = \frac{V_{IN_MAX} - V_{OUT}}{I_{LOAD_MIN} + I_{R_MAX}}$$

$$R_{S_MAX} = \frac{V_{IN_MIN} - V_{OUT}}{I_{LOAD_MAX} + I_{R_MIN}}$$
(2)

9.2.1.3 Application Curve

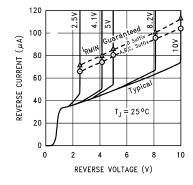


Figure 11. Reverse Characteristics And Minimum Operating Current

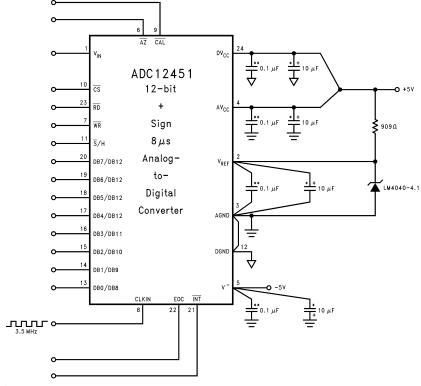
LM4040-N, LM4040-N-Q1

IO-N-Q1

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9.2.2 4.1-V ADC Application



^{**}Ceramic monolithic

Figure 12. 4.1-V LM4040-N'S Nominal 4.096 Breakdown Voltage Gives ADC12451 1 MV/LSB

9.2.2.1 Design Requirements

The only design requirement is for an output voltage of 4.096 V.

9.2.2.2 Detailed Design Procedure

Using an LM4040-4.1, select an appropriate R_S to sufficiently power the device. Set the target I_R for 1 mA. With an input voltage of 5 V, the resistor can be calculated:

$$R = \frac{5 \text{ V} - 4.096 \text{ V}}{1 \text{ mA}} = 904 \Omega \tag{4}$$

The closest available resistance of 909 Ω is used here, which in turn yields an I_R of 994 μ A.

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^{*}Tantalum

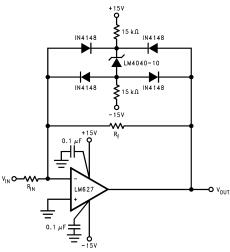


LM4040-N, LM4040-N-Q1

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Typical Applications (continued)

9.2.3 Bounded Amplifier



Nominal clamping voltage is ±11.5 V (LM4040-N's reverse breakdown voltage +2 diode V_F).

Figure 13. Bounded Amplifier Reduces Saturation-Induced Delays and Can Prevent Succeeding Stage Damage

9.2.3.1 Design Requirements

Design an amplifier with output clamped at ±11.5 V.

9.2.3.2 Detailed Design Procedure

With amplifier rails of ± 15 V, the output can be bound to ± 11.5 V with the LM4040-10 and two nominal diode voltage drops of 0.7 V.

$$V_{OUTBound} = 2 \times VFWD + VZ \tag{5}$$

$$V_{OLITROUND} = 1.4 \text{ V} + 10 \text{ V}$$
 (6)

Select $R_S = 15 \text{ k}\Omega$ to keep I_R low. Calculate I_R to confirm RS selection.

$$I_R = (V_{IN} - V_{OLIT}) / R$$
, however in this case, the negative supply must be taken into account. (7)

$$I_{R} = (V_{1N+} - V_{1N-} - V_{OUT})/R = (30 \text{ V} - 10 \text{ V}) / (R_{S1} + R_{S2}) = 20 \text{ V} / 30 \text{ k}\Omega = 0.667 \text{ mA}$$
(8)

This is an acceptable value for I_R that will not draw excessive current, but prevents the part from being starved for current.

Product Folder Links: LM4040-N LM4040-N-Q1

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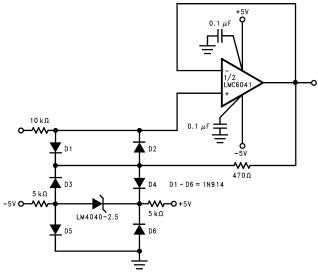
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Typical Applications (continued)

9.2.4 Protecting Op-Amp Input



The bounding voltage is ±4 V with the 2.5-V LM4040-N (LM4040-N's reverse breakdown voltage + 3 diode V_F).

Figure 14. Protecting Op Amp Input

9.2.4.1 Design Requirements

Limit the input voltage to the op-amp to ±4 V.

9.2.4.2 Detailed Design Procedure

Similar to Bounded Amplifier, this design uses a LM4040-2.5 and three forward diode voltage drops to create a voltage clamp. The procedure for selecting the R_S resistors, in this case 5 k Ω , is the same as Detailed Design Procedure.

$$I_R = (V_{IN+} - V_{IN-} - V_{OLT}) / R = (10 \text{ V} - 2.5 \text{ V}) / (R_{S1} + R_{S2}) = 7.5 \text{ V} / 10 \text{ k}\Omega = 0.750 \text{ mA}$$
 (9)

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Typical Applications (continued)

9.2.5 Precision ±4.096-V Reference

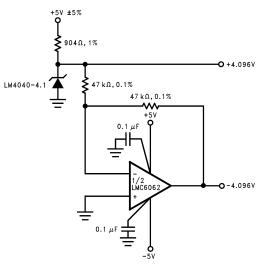


Figure 15. Precision ±4.096-V Reference

9.2.5.1 Design Requirements

Use a single voltage reference to create positive and negative reference rails, ±4.096 V.

9.2.5.2 Detailed Design Procedure

The procedure for selecting the R_S resistor is same as detailed in *Detailed Design Procedure*. The output of the voltage reference is used as the inverting input to the op-amp, with unity gain.

Product Folder Links: LM4040-N LM4040-N-Q1

LM4040-N, LM4040-N-Q1

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Typical Applications (continued)

9.2.6 Precision Current Sink/Source

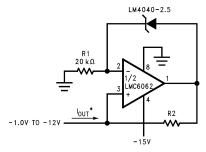


Figure 16. Precision 1-mA Current Sink

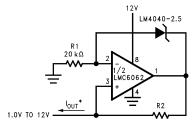


Figure 17. Precision 1-mA Current Source

9.2.6.1 Design Requirements

Create precision 1-mA current sink and/or 1-mA current source.

9.2.6.2 Detailed Design Procedure

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Set R1 such that the current through the shunt reference, I_R, is greater than I_{RMIN}. $I_{OUT} = V_{OUT} / R_2$ where V_{OUT} is the voltage drop across the shunt reference. In this case, $I_{OUT} = 2.5 / R_2$

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INSTRUMENTS

10 Power Supply Recommendations

While a bypass capacitor is not required on the input voltage line, TI recommends reducing noise on the input which could affect the output. A 0.1-µF ceramic capacitor or larger is recommended.

11 Layout

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11.1 Layout Guidelines

Place external components as close to the device as possible. Place RS close the cathode, as well as the input bypass capacitor, if used.

11.2 Layout Example

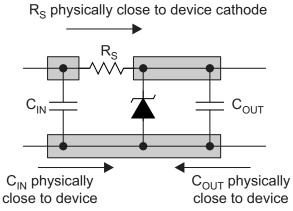


Figure 18. Layout Diagram

LM4040-N, LM4040-N-Q1



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12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

For related documentation, see the following:

LM4041-N/LM4041-N-Q1 Precision Micropower Shunt Voltage Reference, SNOS641

12.2 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY	
LM4040-N	Click here	Click here	Click here	Click here	Click here	
LM4040-N-Q1	Click here	Click here	Click here	Click here	Click here	
LM4040-N-Q1	Click here	Click here	Click here	Click here	Click here	

12.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views: see TI's Terms of

TI E2E™ Online Community TI's Engineer-to-Engineer (E2E) Community. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support TI's Design Support Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.4 Trademarks

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

12.5 Electrostatic Discharge Caution

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

12.6 Glossary

SLYZ022 — TI Glossarv.

This glossary lists and explains terms, acronyms, and definitions.

13 Mechanical, Packaging, And Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

13.1 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.

First Field:

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