参考資料

LM4040 高精度マイクロパワー シャント電圧リファレンス

1 特長

- 2.048V、2.5V、3V、4.096V、5V、8.192V、10V の固定出力電圧
- 厳しい出力許容誤差と小さい温度係数
  - 最大 0.1%、100ppm/°C – A グレード
  - 最大 0.2%、100ppm/°C – B グレード
  - 最大 0.5%、100ppm/°C – C グレード
  - 最大 1.0%、150ppm/°C – D グレード
- 低い出力ノイズ:35μV_{RMS} (標準値)
- 広い動作電流範囲:15mA に対し 45μA (標準値)
- 容量性負荷の大小にかかわらず安定して動作するため、出力コンデンサは不要
- 拡張温度範囲で利用可能:-40℃ ～ 125℃

2 アプリケーション

- データ アクイジション システム
- エネルギー インフラ
- アナログ入力モジュール
- フィールド トランスミッタ
- 高精度オーディオ
- 車載用電子機器

3 概要

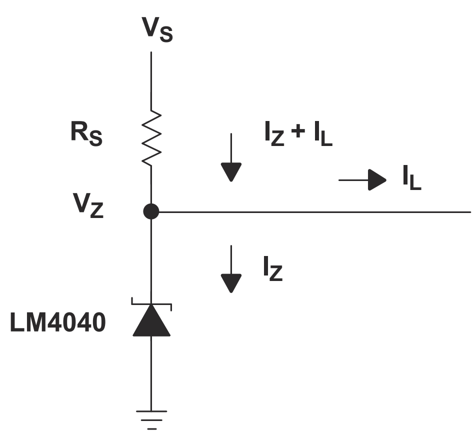
LM4040 シリーズのシャント電圧リファレンスは、多様なアプリケーション向けに作られた、汎用性が高く使いやすい基準電圧です。これは 2 ピンの固定出力デバイスで、外付けコンデンサを必要とせず、容量性負荷の大小にかかわらず安定して動作します。また、この基準電圧はダイナミック インピーダンス、ノイズ、温度係数が小さく、広範囲の動作電流および温度にわたって安定した電圧を維持します。LM4040 では、ウェハー ソート時のヒューズとツェナーザップ逆方向ブレークダウンによる電圧調整を使用して、最大 0.1% (A グレード) から最大 1% (D グレード) までの 4 種類の出力電圧許容誤差の製品を提供しています。このため、アプリケーションに適した最良のコスト / 性能比を非常に柔軟に選択できます。

省スペースの SC-70 と SOT-23-3 にパッケージ化され、最低電流 45μF (標準値) で動作する LM4040 は、ポータブル アプリケーションを考慮して設計されています。LM4040xI は –40℃～85℃の周囲温度範囲で動作します。LM4040xQ は –40℃～125℃の周囲温度範囲で動作します。

製品情報

部品番号	パッケージ (ピン) (1)	本体サイズ (公称)(2)
LM4040	SOT-23 (3)	2.92mm × 1.30mm
	SC70 (6)	2.00mm × 1.25mm

(1) 利用可能なすべてのパッケージについては、データシートの末尾にある注文情報を参照してください。
(2) パッケージ サイズ (長さ × 幅) は公称値であり、該当する場合はピンも含まれます。



概略回路図

このリソースの元の言語は英語です。翻訳は概要を便宜的に提供するもので、自動化ツール (機械翻訳) を使用していることがあり、TI では翻訳の正確性および妥当性につきましては一切保証いたしません。実際の設計などの前には、ti.com で必ず最新の英語版をご参照くださいますようお願いいたします。

English Data Sheet: SLOS456

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4 Device Comparison Table

T_A	DEVICE GRADE	V_{KA}	ORDERABLE [(1)] PART NUMBER
–40°C to 85°C	A grade: 0.1% initial accuracy and 100 ppm/°C temperature coefficient	2.048V	LM4040A20I
		2.5V	LM4040A25I
		3V	LM4040A30I
		4.096V	LM4040A41I
		5V	LM4040A50I
		8.192V	LM4040A82I
		10V	LM4040A10I
	B grade: 0.2% initial accuracy and 100 ppm/°C temperature coefficient	2.048V	LM4040B20I
		2.5V	LM4040B25I
		3V	LM4040B30I
		4.096V	LM4040B41I
		5V	LM4040B50I
		8.192V	LM4040B82I
		10V	LM4040B10I
–40°C to 85°C	C grade: 0.5% initial accuracy and 100 ppm/°C temperature coefficient	2.048V	LM4040C20I
		2.5V	LM4040C25I
		3V	LM4040C30I
		4.096V	LM4040C41I
		5V	LM4040C50I
		8.192V	LM4040C82I
		10V	LM4040C10I
–40°C to 85°C	D grade: 1.0% initial accuracy and 150 ppm/°C temperature coefficient	2.048V	LM4040D20I
		2.5V	LM4040D25I
		3V	LM4040D30I
		4.096V	LM4040D41I
		5V	LM4040D50I
		8.192V	LM4040D82I
		10V	LM4040D10I
–40°C to 125°C	C grade: 0.5% initial accuracy and 100 ppm/°C temperature coefficient	2.048V	LM4040C20Q
		2.5V	LM4040C25Q
		3V	LM4040C30Q
		5V	LM4040C50Q
	D grade: 1.0% initial accuracy and 150 ppm/°C temperature coefficient	2.048V	LM4040D20Q
		2.5V	LM4040D25Q
		3V	LM4040D30Q
		5V	LM4040D50Q

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

5 Pin Configuration and Functions

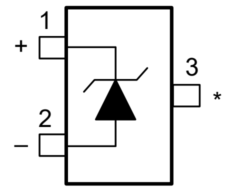

図 5-1. DBZ Package
3-Pin SOT-23
Top View

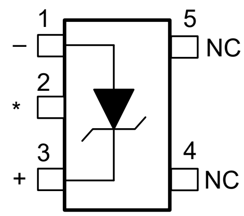

図 5-2. DCK Package
5-Pin SC70
Top View

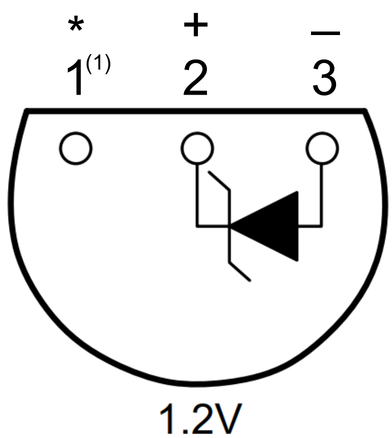

図 5-3. LP Package
3-Pin TO-92
Bottom View

Pin Functions

PIN				TYPE	DESCRIPTION
NAME	DBZ	DCK	TO-92		
CATHODE	1	3	2	I/O	Shunt Current/Voltage input
ANODE	2	1	3	O	Common pin, normally connected to ground
NC	—	4, 5	—	I	No Internal Connection
*	3	2	1	I	Must float or connect to anode(1).

(1) **In applications with high electromagnetic interference (for example, when placed near transformers or other electromagnetic sources) or significant high-frequency switching noise, TI recommends connecting this pin to the anode.**

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6 Specifications

6.1 Absolute Maximum Ratings

over free-air temperature range (unless otherwise noted)[(1)]

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

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *セクション 6.3* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins[(1)]	±2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins[(2)]	±500	

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

6.3 Recommended Operating Conditions

			MIN	MAX	UNIT
I_Z	Cathode current		[(1)]	15	mA
T_A	Free-air temperature	LM4040xxxI	–40	85	°C
		LM4040xxxQ	–40	125	

(1) See parametric tables

6.4 Thermal Information

THERMAL METRIC[(1)]		LM4040		UNIT
		DBZ	DCK	
		3 PINS	5 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	206	252	°C/W

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

6.5 LM4040A20I, LM4040B20I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040A20I			LM4040B20I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100μA	25°C		2.048			2.048		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100μA	25°C	–2		2	–4.1		4.1	mV
			Full range	–15		15	–17		17	
$I_{Z,min}$	Minimum cathode current		25°C		45	75		45	75	μA
			Full range			80			80	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±20			±20		ppm/°C
		I_Z = 1mA	25°C		±15			±15		
			Full range			±100			±100	
		I_Z = 100μA	25°C		±15			±15		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.3	0.8		0.3	0.8	mV
			Full range			1			1	
		1mA $< I_Z <$ 15mA	25°C		2.5	6		2.5	6	
			Full range			8			8	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.3	0.8		0.3	0.8	Ω
e_N	Wideband noise	I_Z = 100μA, 10Hz ≤ f ≤ 10kHz	25°C		35			35		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100μA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.6 LM4040C20I, LM4040D20I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C20I			LM4040D20I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100µA	25°C		2.048			2.048		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100µA	25°C	–10		10	–20		20	mV
			Full range	–23		23	–40		40	
$I_{Z,min}$	Minimum cathode current		25°C		45	75		45	75	µA
			Full range			80			80	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±20			±20		ppm/°C
		I_Z = 1mA	25°C		±15			±15		
			Full range			±100			±150	
		I_Z = 100µA	25°C		±15			±15		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.3	0.8		0.3	1	mV
			Full range			1			1.2	
		1mA < I_Z < 15mA	25°C		2.5	6		2.5	8	
			Full range			8			10	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.3	0.9		0.3	1.1	Ω
e_N	Wideband noise	I_Z = 100µA, 10Hz ≤ f ≤ 10kHz	25°C		35			35		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100µA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.7 LM4040C20Q, LM4040D20Q Electrical Characteristics

at extended temperature range, full-range T_A = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C20Q MIN	LM4040C20Q TYP	LM4040C20Q MAX	LM4040D20Q MIN	LM4040D20Q TYP	LM4040D20Q MAX	UNIT
V_Z	Reverse breakdown voltage	I_Z = 100μA	25°C		2.048			2.048		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100μA	25°C	–10		10	–20		20	mV
			Full range	–30		30	–50		50	
$I_{Z,min}$	Minimum cathode current		25°C		45	75		45	75	μA
			Full range			80			80	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±20			±20		ppm/°C
		I_Z = 1mA	25°C		±15			±15		
			Full range			±100			±150	
		I_Z = 100μA	25°C		±15			±15		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.3	0.8		0.3	1	mV
			Full range			1			1.2	
		1mA < I_Z < 15mA	25°C		2.5	6		2.5	8	
			Full range			8			10	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.3	0.9		0.3	1.1	Ω
e_N	Wideband noise	I_Z = 100μA, 10Hz ≤ f ≤ 10kHz	25°C		35			35		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100μA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.8 LM4040A25I, LM4040B25I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040A25I			LM4040B25I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100µA	25°C		2.5			2.5		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100µA	25°C	–2.5		2.5	–5		5	mV
			Full range	–19		19	–21		21	
$I_{Z,min}$	Minimum cathode current		25°C		45	75		45	75	µA
			Full range			80			80	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage [(2)]	I_Z = 10mA	25°C		±20			±20		ppm/°C
		I_Z = 1mA	25°C		±15			±15		
			Full range			±100			±100	
		I_Z = 100µA	25°C		±15			±15		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.3	0.8		0.3	0.8	mV
			Full range			1			1	
		1mA < I_Z < 15mA	25°C		2.5	6		2.5	6	
			Full range			8			8	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.3	0.8		0.3	0.8	Ω
e_N	Wideband noise	I_Z = 100µA, 10Hz ≤ f ≤ 10kHz	25°C		35			35		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100µA			120			120		ppm
V_{HYST}	Thermal hysteresis[(1)]	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

6.9 LM4040C25I, LM4040D25I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C25I			LM4040D25I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100μA	25°C		2.5			2.5		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100μA	25°C	–12		12	–25		25	mV
			Full range	–29		29	–49		49	
$I_{Z,min}$	Minimum cathode current		25°C		45	75		45	75	μA
			Full range			80			80	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±20			±20		ppm/°C
		I_Z = 1mA	25°C		±15			±15		
			Full range			±100			±150	
		I_Z = 100μA	25°C		±15			±15		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.3	0.8		0.3	1	mV
			Full range			1			1.2	
		1mA < I_Z < 15mA	25°C		2.5	6		2.5	8	
			Full range			8			10	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.3	0.9		0.3	1.1	Ω
e_N	Wideband noise	I_Z = 100μA, 10Hz ≤ f ≤ 10kHz	25°C		35			35		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100μA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.10 LM4040C25Q, LM4040D25Q Electrical Characteristics

at extended temperature range, full-range T_A = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C25Q			LM4040D25Q			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100μA	25°C		2.5			2.5		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100μA	25°C	–12		12	–25		25	mV
			Full range	–38		38	–63		63	
$I_{Z,min}$	Minimum cathode current		25°C		45	75		45	75	μA
			Full range			80			80	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±20			±20		ppm/°C
		I_Z = 1mA	25°C		±15			±15		
			Full range			±100			±150	
		I_Z = 100μA	25°C		±15			±15		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.3	0.8		0.3	1	mV
			Full range			1			1.2	
		1mA < I_Z < 15mA	25°C		2.5	6		2.5	8	
			Full range			8			10	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.3	0.9		0.3	1.1	Ω
e_N	Wideband noise	I_Z = 100μA, 10Hz ≤ f ≤ 10kHz	25°C		35			35		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100μA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

6.11 LM4040A30I, LM4040B30I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040A30I			LM4040B30I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100µA	25°C		3			3		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100µA	25°C	–3		3	–6		6	mV
			Full range	–22		22	–26		26	
$I_{Z,min}$	Minimum cathode current		25°C		47	77		47	77	µA
			Full range			82			82	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±20			±20		ppm/°C
		I_Z = 1mA	25°C		±15			±15		
			Full range			±100			±100	
		I_Z = 100µA	25°C		±15			±15		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.6	0.8		0.6	0.8	mV
			Full range			1.1			1.1	
		1mA $< I_Z <$ 15mA	25°C		2.7	6		2.7	6	
			Full range			9			9	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.4	0.9		0.4	0.9	Ω
e_N	Wideband noise	I_Z = 100µA, 10Hz ≤ f ≤ 10kHz	25°C		35			35		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100µA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.12 LM4040C30I, LM4040D30I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C30I			LM4040D30I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100µA	25°C		3			3		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100µA	25°C	–15		15	–30		30	mV
			Full range	–34		34	–59		59	
$I_{Z,min}$	Minimum cathode current		25°C		45	77		45	77	µA
			Full range			82			82	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±20			±20		ppm/°C
		I_Z = 1mA	25°C		±15			±15		
			Full range			±100			±150	
		I_Z = 100µA	25°C		±15			±15		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z < 1mA$	25°C		0.4	0.8		1.4	1	mV
			Full range			1.1			1.3	
		$1mA < I_Z < 15mA$	25°C		2.7	6		2.7	8	
			Full range			9			11	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, $I_{AC} = 0.1\ I_Z$	25°C		0.4	0.9		0.4	1.2	Ω
e_N	Wideband noise	I_Z = 100µA, 10Hz ≤ f ≤ 10kHz	25°C		35			35		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100µA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) 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, 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.13 LM4040C30Q, LM4040D30Q Electrical Characteristics

at extended temperature range, full-range T_A = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C30Q			LM4040D30Q			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100µA	25°C		3			3		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100µA	25°C	–15		15	–30		30	mV
			Full range	–45		45	–75		75	
$I_{Z,min}$	Minimum cathode current		25°C		47	77		47	77	µA
			Full range			82			82	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±20			±20		ppm/°C
		I_Z = 1mA	25°C		±15			±15		
			Full range			±100			±150	
		I_Z = 100µA	25°C		±15			±15		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.4	0.8		0.4	1.1	mV
			Full range			1.1			1.3	
		1mA < I_Z < 15mA	25°C		2.7	6		2.7	8	
			Full range			9			11	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.4	0.9		0.4	1.2	Ω
e_N	Wideband noise	I_Z = 100µA, 10Hz ≤ f ≤ 10kHz	25°C		35			35		$µV_{RMS}$
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100µA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.14 LM4040A41I, LM4040B41I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040A41I			LM4040B41I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100µA	25°C		4.096			4.096		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100µA	25°C	–4.1		4.1	–8.2		8.2	mV
			Full range	–31		31	–35		35	
$I_{Z,min}$	Minimum cathode current		25°C		50	83		50	83	µA
			Full range			88			88	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage [(2)]	I_Z = 10mA	25°C		±30			±30		ppm/°C
		I_Z = 1mA	25°C		±20			±20		
			Full range			±100			±100	
		I_Z = 100µA	25°C		±20			±20		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.5	0.9		0.5	0.9	mV
			Full range			1.2			1.2	
		1mA < I_Z < 15mA	25°C		3	7		3	7	
			Full range			10			10	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.5	1		0.5	1	Ω
e_N	Wideband noise	I_Z = 100µA, 10Hz ≤ f ≤ 10kHz	25°C		80			80		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100µA			120			120		ppm
V_{HYST}	Thermal hysteresis[(1)]	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

6.15 LM4040C41I, LM4040D41I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C41I			LM4040D41I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100µA	25°C		4.096			4.096		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100µA	25°C	–20		20	–41		41	mV
			Full range	–47		47	–81		81	
$I_{Z,min}$	Minimum cathode current		25°C		50	83		50	83	µA
			Full range			88			88	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±30			±30		ppm/°C
		I_Z = 1mA	25°C		±20			±20		
			Full range			±100			±150	
		I_Z = 100µA	25°C		±20			±20		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.5	0.9		0.5	1.2	mV
			Full range			1.2			1.5	
		1mA < I_Z < 15mA	25°C		3	7		3	9	
			Full range			10			13	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.5	1		0.5	1.3	Ω
e_N	Wideband noise	I_Z = 100µA, 10Hz ≤ f ≤ 10kHz	25°C		80			80		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100µA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.16 LM4040A50I, LM4040B50I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040A50I			LM4040B50I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100µA	25°C		5			5		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100µA	25°C	–5		5	–10		10	mV
			Full range	–38		38	–43		43	
$I_{Z,min}$	Minimum cathode current		25°C		65	89		65	89	µA
			Full range			95			95	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±30			±30		ppm/°C
		I_Z = 1mA	25°C		±20			±20		
			Full range			±100			±100	
		I_Z = 100µA	25°C		±20			±20		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z < 1mA$	25°C		0.5	1		0.5	1	mV
			Full range			1.4			1.4	
		$1mA < I_Z < 15mA$	25°C		3.5	8		3.5	8	
			Full range			12			12	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, $I_{AC} = 0.1\ I_Z$	25°C		0.5	1.1		0.5	1.1	Ω
e_N	Wideband noise	I_Z = 100µA, 10Hz ≤ f ≤ 10kHz	25°C		80			80		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100µA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

6.17 LM4040C50I, LM4040D50I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C50I			LM4040D50I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100µA	25°C		5			5		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100µA	25°C	–25		25	–50		50	mV
			Full range	–58		58	–99		99	
$I_{Z,min}$	Minimum cathode current		25°C		65	89		65	89	µA
			Full range			95			95	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±30			±30		ppm/°C
		I_Z = 1mA	25°C		±20			±20		
			Full range			±100			±150	
		I_Z = 100µA	25°C		±20			±20		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.5	1		0.5	1.3	mV
			Full range			1.4			1.8	
		1mA < I_Z < 15mA	25°C		3.5	8		3.5	10	
			Full range			12			15	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.5	1.1		0.5	1.5	Ω
e_N	Wideband noise	I_Z = 100µA, 10Hz ≤ f ≤ 10kHz	25°C		80			80		µV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100µA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.18 LM4040C50Q, LM4040D50Q Electrical Characteristics

at extended temperature range, full-range T_A = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C50Q			LM4040D50Q			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 100μA	25°C		5			5		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 100μA	25°C	–25		25	–50		50	mV
			Full range	–75		75	–125		125	
$I_{Z,min}$	Minimum cathode current		25°C		65	89		65	89	μA
			Full range			95			95	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±30			±30		ppm/°C
		I_Z = 1mA	25°C		±20			±20		
			Full range			±100			±150	
		I_Z = 100μA	25°C		±20			±20		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.5	1		0.5	1	mV
			Full range			1.4			1.8	
		1mA < I_Z < 15mA	25°C		3.5	8		3.5	8	
			Full range			12			12	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.5	1.1		0.5	1.1	Ω
e_N	Wideband noise	I_Z = 100μA, 10Hz ≤ f ≤ 10kHz	25°C		80			80		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 100μA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

6.19 LM4040A82I, LM4040B82I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	T_A	LM4040A82I MIN	LM4040A82I TYP	LM4040A82I MAX	LM4040B82I MIN	LM4040B82I TYP	LM4040B82I MAX	UNIT
V_Z	Reverse breakdown voltage	I_Z = 150μA	25°C		8.192			8.192		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 150μA	25°C	–8.2		8.2	–16		16	mV
			Full range	–61		61	–70		70	
$I_{Z,min}$	Minimum cathode current		25°C		67	106		67	106	μA
			Full range			110			110	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±40			±40		ppm/°C
		I_Z = 1mA	25°C		±20			±20		
			Full range			±100			±100	
		I_Z = 150μA	25°C		±20			±20		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.6	1.3		0.6	1.6	mV
			Full range			2.5			2.5	
		1mA < I_Z < 15mA	25°C		7	10		7	10	
			Full range			18			18	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.6	1.5		0.6	1.5	Ω
e_N	Wideband noise	I_Z = 150μA, 10Hz ≤ f ≤ 10kHz	25°C		130			130		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 150μA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.20 LM4040C82I, LM4040D82I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C82I			LM4040D82I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 150µA	25°C		8.192			8.192		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 150µA	25°C	–41		41	–82		82	mV
			Full range	–94		94	–162		162	
$I_{Z,min}$	Minimum cathode current		25°C		67	106		67	111	µA
			Full range			110			115	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage [2]	I_Z = 10mA	25°C		±40			±40		ppm/°C
		I_Z = 1mA	25°C		±20			±20		
			Full range			±100			±150	
		I_Z = 150µA	25°C		±20			±20		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.6	1.3		0.6	1.7	mV
			Full range			2.5			3	
		1mA $< I_Z <$ 15mA	25°C		7	10		7	15	
			Full range			18			24	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.6	1.5		0.6	1.9	Ω
e_N	Wideband noise	I_Z = 150µA, 10Hz ≤ f ≤ 10kHz	25°C		130			130		$µV_{RMS}$
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 150µA			120			120		ppm
V_{HYST}	Thermal hysteresis[1]	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.21 LM4040A10I, LM4040B10I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040A10I			LM4040B10I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 150µA	25°C		10			10		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 150µA	25°C	–10		10	–20		20	mV
			Full range	–75		75	–85		85	
$I_{Z,min}$	Minimum cathode current		25°C		75	120		75	120	µA
			Full range			125			125	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±40			±40		ppm/°C
		I_Z = 1mA	25°C		±20			±20		
			Full range			±100			±100	
		I_Z = 150µA	25°C		±20			±20		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.8	1.5		0.8	1.5	mV
			Full range			3.8			3.8	
		1mA < I_Z < 15mA	25°C		8	14		8	14	
			Full range			24			24	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.7	1.7		0.7	1.7	Ω
e_N	Wideband noise	I_Z = 150µA, 10Hz ≤ f ≤ 10kHz	25°C		180			180		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 150µA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) The overtemperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(maxΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.22 LM4040C10I, LM4040D10I Electrical Characteristics

at industrial temperature range, full-range T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LM4040C10I			LM4040D10I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reverse breakdown voltage	I_Z = 150µA	25°C		10			10		V
ΔV_Z	Reverse breakdown voltage tolerance	I_Z = 150µA	25°C	–50		50	–100		100	mV
			Full range	–115		115	–198		198	
$I_{Z,min}$	Minimum cathode current		25°C		75	120		75	130	µA
			Full range			125			135	
α_{VZ}	Average temperature coefficient of reverse breakdown voltage (2)	I_Z = 10mA	25°C		±40			±40		ppm/°C
		I_Z = 1mA	25°C		±20			±20		
			Full range			±100			±150	
		I_Z = 150µA	25°C		±20			±20		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,min} < I_Z <$ 1mA	25°C		0.8	1.5		0.8	2	mV
			Full range			3.8			4	
		1mA < I_Z < 15mA	25°C		8	14		8	18	
			Full range			24			29	
Z_Z	Reverse dynamic impedance	I_Z = 1mA, f = 120Hz, I_{AC} = 0.1 I_Z	25°C		0.7	1.7		0.7	2.3	Ω
e_N	Wideband noise	I_Z = 150µA, 10Hz ≤ f ≤ 10kHz	25°C		180			180		μV_{RMS}
	Long-term stability of reverse breakdown voltage	t = 1000 h, T_A = 25°C ± 0.1°C, I_Z = 150µA			120			120		ppm
V_{HYST}	Thermal hysteresis(1)	ΔT_A = –40°C to 125°C			0.08%			0.08%		—

(1) 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.

(2) 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, 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: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
The total overtemperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade 2.5V LM4040 has an overtemperature Reverse Breakdown Voltage tolerance of ±2.5V × 0.75% = ±19mV.

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6.23 Typical Characteristics

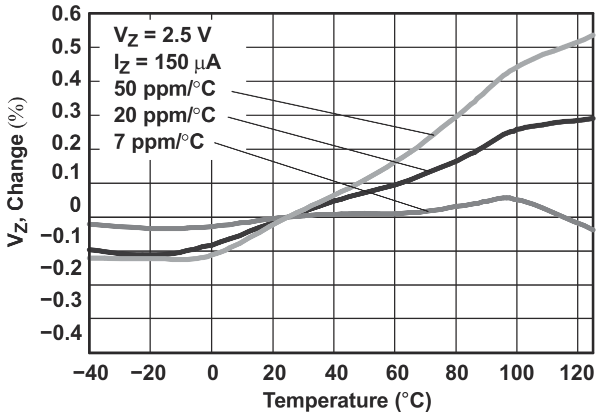

図 6-1. Temperature Drift for Different Average Temperature Coefficients

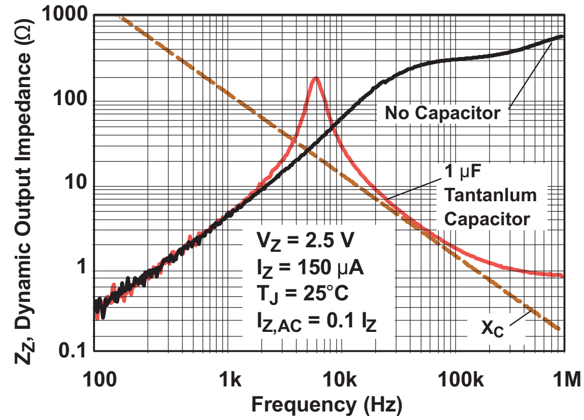

図 6-2. Output Impedance vs Frequency

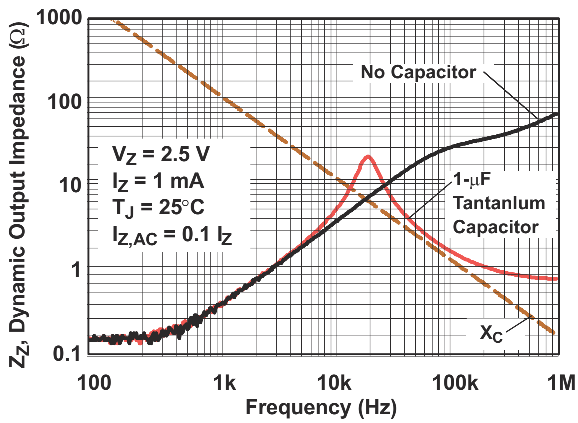

図 6-3. Output Impedance vs Frequency

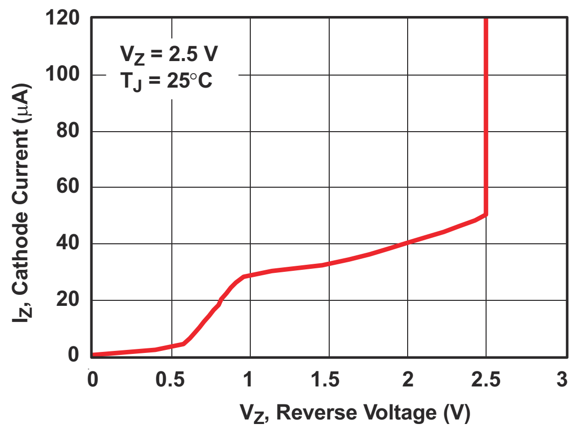

図 6-4. Cathode Current vs. Reverse Voltage

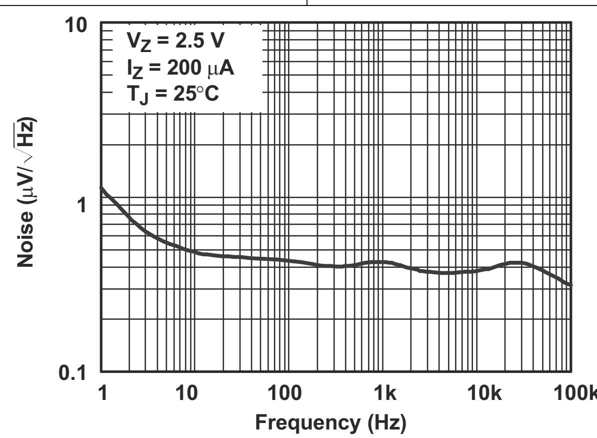

図 6-5. Noise Voltage vs Frequency

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7 Detailed Description

7.1 Overview

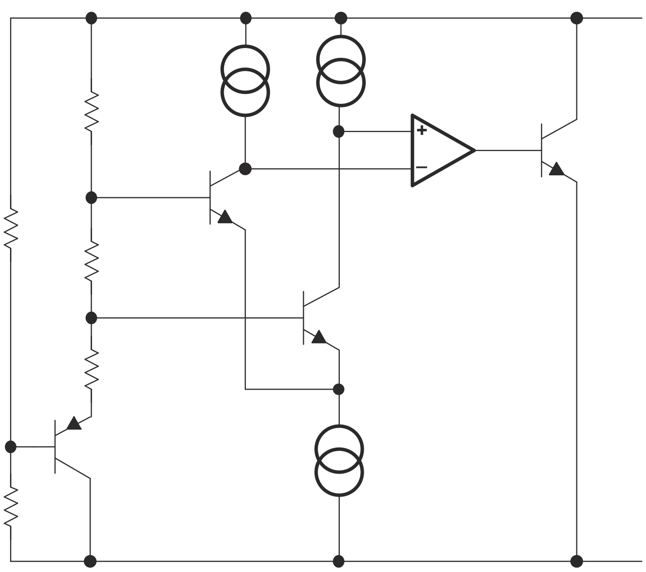
The LM4040 is a precision micro-power curvature-corrected bandgap shunt voltage reference. The LM4040 has been designed for stable operation without the need of an external capacitor connected between the "+" pin and the "−" pin. If, however, a bypass capacitor is used, the LM4040 remains stable.

LM4040 offers several fixed reverse breakdown voltages: 2.048V, 2.500V, 3.000V, 4.096V, 5.000V, 6.000, 8.192V, and 10.000V. The minimum operating current increases from 60μA for the LM4040-N-2.048 and LM4040-N-2.5 to 100μA for the 10.0V LM4040. All versions have a maximum operating current of 15mA.

Each reverse voltage options can be purchased with initial tolerances (at 25°C) of 0.1%, 0.2%, 0.5% and 1.0%. These reference options are denoted by A (0.1%), B (0.2%), C (0.5%) and D for (1.0%).

The LM4040xxxI devices are characterized for operation from –40°C to 85°C, and the LM4040xxxQ devices are characterized for operation from –40°C to 125°C.

7.2 Functional Block Diagram



7.3 Feature Description

A temperature compensated band gap voltage reference controls high gain amplifier and shunt pass element to maintain a nearly constant voltage between cathode and anode. Regulation occurs after a minimum current is provided to power the voltage divider and amplifier. Internal frequency compensation provides a stable loop for all capacitor loads. Floating shunt design is useful for both positive and negative regulation applications.

7.4 Device Functional Modes

7.4.1 Shunt Reference

LM4040 does not operate in one mode, which is as a fixed voltage reference that cannot be adjusted. LM4040 does offer various Reverse Voltage options that have unique electrical characteristics detailed in *セクション 6*.

For a proper Reverse Voltage to be developed, current must be sourced into the cathode of LM4040. The minimum current needed for proper regulation is denoted in *セクション 6* as $I_{Z,min}$.

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8 Applications and Implementation

注

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8.1 Application Information

LM4040 is a well known industry standard device used in several applications and end equipment where a reference is required. Below describes this device being used in a data acquisition system. Analog to Digital conversion systems are the most common applications to use LM4040 due to the devices low reference tolerance which allows high precision in these systems.

8.2 Typical Applications

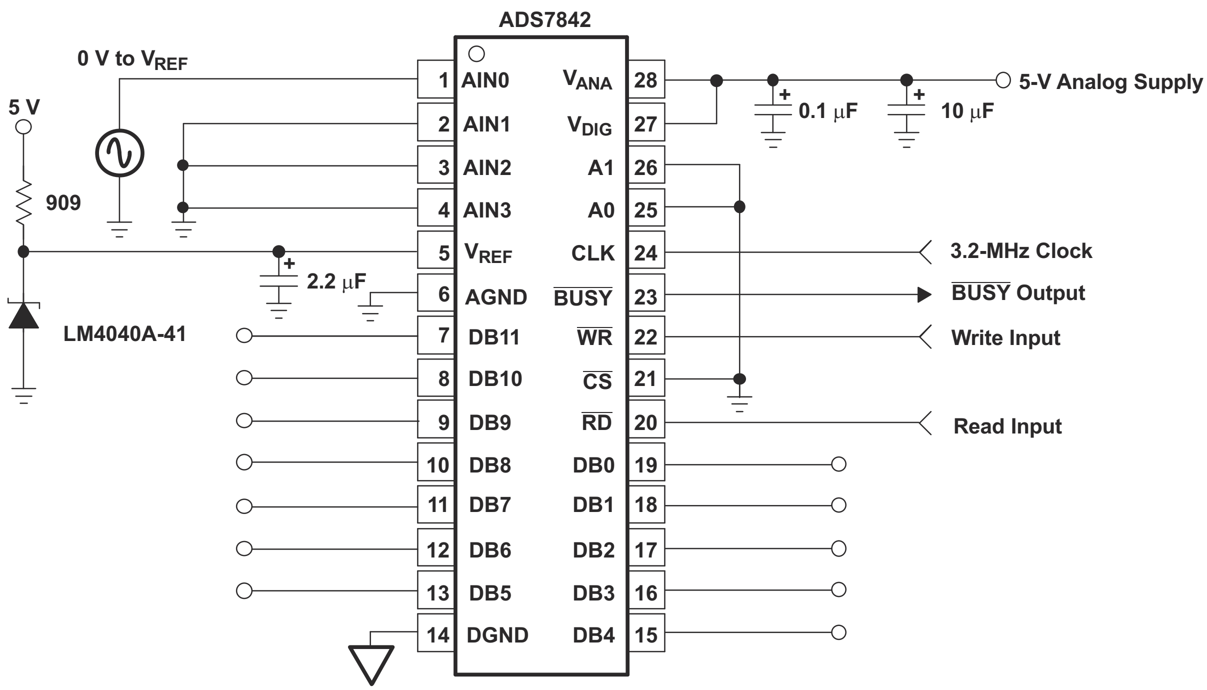

図 8-1. Data-Acquisition Circuit With LM4040x-41

8.2.1 Design Requirements

For this design example, use the parameters listed in 表 8-1 as the input parameters.

表 8-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
ADC FSR (Full Scale Range)	4.096
ADC Resolution	12 Bits
Supply Voltage	5V
Cathode Current (Ik)	100µA

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8.2.2 Detailed Design Procedure

When using LM4040 as a comparator with reference, determine the following:

- Input voltage range
- Reference voltage accuracy
- Output logic input high and low level thresholds
- Current source resistance

8.2.2.1 LM4040 Voltage and Accuracy Choice

When using LM4040 as a reference for an ADC, the ADC's FSR (Full Scale Range), Resolution and LSB must be determined. LSB can be determined by:

LSB=FSR/(2^{N}-1)

With N being the resolution or Number of Bits. FSR and Resolution can be determined by the ADC's data sheet.

Vref can be determined by:

Vref=FSR+LSB

Though modern data converters use calibration techniques to compensate for any error introduced by a Vref's inaccuracy, use the highest accuracy available. This is due to errors in the calibration method that can allow some non-linearity introduced by the Vref's initial accuracy.

A good example is the LM4040x-41 that is designed to be a cost-effective voltage reference as required in 12-bit data-acquisition systems. For 12-bit systems operating from 5V supplies (see 図 8-1), the LM4040A-41 (4.096V, 0.01%) only introduces 4 LSBs (4mV) of possible error in a system that consists of 4096 LSBs.

8.2.2.2 Cathode and Load Currents

In a typical shunt-regulator configuration (see 図 8-2), an external resistor, R_S, is connected between the supply and the cathode of the LM4040. R_S must be set properly, as R_S sets the total current available to supply the load (I_L) and bias the LM4040 (I_Z). In all cases, I_Z must stay within a specified range for proper operation of the reference. Taking into consideration one extreme in the variation of the load and supply voltage (maximum I_L and minimum V_S), R_S must be small enough to supply the minimum I_Z required for operation of the regulator, as given by data-sheet parameters. At the other extreme, maximum V_S and minimum I_L, R_S must be large enough to limit I_Z to less than the maximum-rated value of 15mA.

R_S is calculated according to 式 1:

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

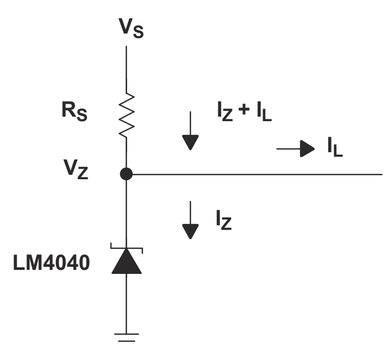

図 8-2. Shunt Regulator

8.2.2.3 Output Capacitor

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

8.2.2.4 SOT-23 Connections

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

8.2.2.5 Start-Up Characteristics

In any data conversion system, start-up characteristics are important, as to determine when to safely begin conversion based upon a steady and settled reference value. As shown in 図 8-4 allow >20µs from supply start-up to begin conversion.

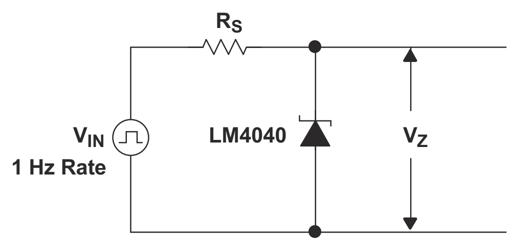

図 8-3. Test Circuit

8.2.3 Application Curve

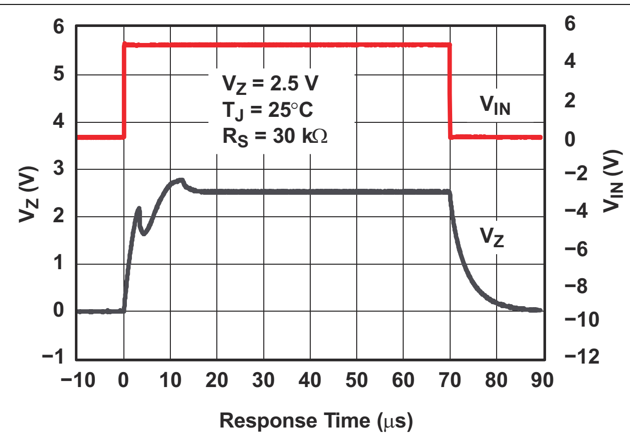

図 8-4. Startup Response

8.3 Power Supply Recommendations

To not exceed the maximum cathode current, be sure that the supply voltage is current limited.

For applications shunting high currents (15mA max), pay attention to the cathode and anode trace lengths, adjusting the width of the traces to have the proper current density.

8.4 Layout

8.4.1 Layout Guidelines

図 8-5 shows an example of a PCB layout of LM4040XXXDBZ. Some key V_{ref} noise considerations are:

- Connect a low ESR, 0.1µF (C_L) ceramic bypass capacitor on the cathode pin node.
- Decouple other active devices in the system per the device specifications.
- Using a solid ground plane helps distribute heat and reduces electromagnetic interference (EMI) noise pickup.

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- Place the external components as close to the device as possible. This configuration prevents parasitic errors (such as the Seebeck effect) from occurring.
- Do not run sensitive analog traces in parallel with digital traces. Avoid crossing digital and analog traces if possible and only make perpendicular crossings when absolutely necessary.

8.4.2 Layout Example

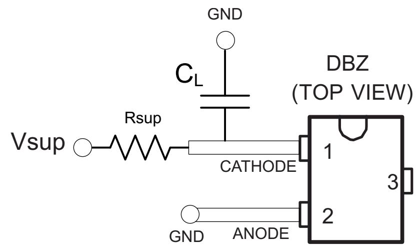

図 8-5. DBZ Layout example

9 Device and Documentation Support

9.1 Related Links

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

表 9-1. Related Links

PARTS	PRODUCT FOLDER	ORDER NOW	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
LM4040A	Click here	Click here	Click here	Click here	Click here
LM4040B	Click here	Click here	Click here	Click here	Click here
LM4040C	Click here	Click here	Click here	Click here	Click here
LM4040D	Click here	Click here	Click here	Click here	Click here

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9.4 用語集

テキサス・インスツルメンツ用語集　　この用語集には、用語や略語の一覧および定義が記載されています。

10 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision O (June 2024) to Revision P (March 2025) — **Page**

- Updated pinout diagrams 4
- Updated CDM ESD ratings........ 5
- Updated reverse breakdown voltage change with cathode current change........ 22
- Updated reverse breakdown voltage change with cathode current change........ 23

Changes from Revision N (October 2017) to Revision O (June 2024) — **Page**

- ドキュメント全体にわたって表、図、相互参照の採番方法を更新。........ 1

Changes from Revision M (January 2015) to Revision N (October 2017) — **Page**

- 標準型番を変更しより短いリスト (LM4040A/B/C/D) を追加........ 1
- Added Average temperature coefficient of reverse breakdown voltage footnote to all electrical tables........ 6
- Changed Thermal hysteresis in electrical characteristics tables........ 6

Changes from Revision L (January 2009) to Revision M (January 2015) — **Page**

- 「*アプリケーション*」セクション、「*製品情報*」表、「*端子機能*」表、「*ESD 定格*」表、「*熱に関する情報*」表、「*機能説明*」セクション、「*デバイスの機能モード*」セクション、「*アプリケーションと実装*」セクション、「*電源に関する推奨事項*」セクショ

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11 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.

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