

AUTOMOTIVE GRADE PRECISION MICROPOWER SHUNT VOLTAGE REFERENCES

Description

The LM4040Q is a family of bandgap circuits designed to achieve precision micro-power voltage references of 2.5V, 3.0V and 5.0V. The devices are available in 0.2% B-grade, 0.5% C-grade and 1% D-grade initial tolerances.

They are available in small outline SOT23 surface mount package which is ideal for applications where space is at a premium. Excellent performance is maintained over the 60µA to 15mA operating current range with a typical temperature coefficient of only 20ppm/°C. The device has been designed to be highly tolerant of capacitive loads therefore maintaining excellent stability.

This device offers a pin for pin compatible alternative to the industry standard LM4040 voltage reference for automotive applications.

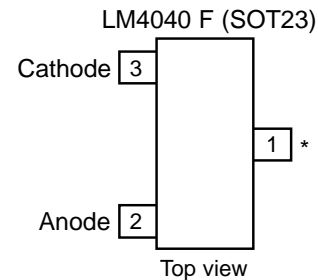
The LM4040Q has been qualified to AEC-Q100 Grade 1 and is Automotive Grade supporting PPAPs

Features

- Small packages: SOT23
- No output capacitor required
- Output voltage tolerance
 - LM4040BQ ±0.2% at +25°C
 - LM4040CQ ±0.5% at +25°C
 - LM4040DQ ±1% at +25°C
- Low output noise
- 10Hz to 10kHz... 45µVRMS
- Wide operating current range 60µA to 15mA
- Extended temperature range -40°C to +125°C
- Low temperature coefficient 100 ppm/°C (max)
- Green Molding in SOT23
 - **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
 - **Halogen and Antimony Free. "Green" Device (Note 3)**
- Automotive Grade
 - **Qualified to AEC-Q100 Standards for High Reliability**
 - **PPAP Capable (Note 4)**

- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
 4. Automotive products are AEC-Q100 qualified and are PPAP capable. Automotive, AEC-Q100 and standard products are electrically and thermally the same, except where specified. For more information, please refer to http://www.diodes.com/quality/product_compliance_definitions/.

Pin Assignments



* Pin 1 must be left floating or connected to pin 2

Applications

- Automotive reference voltage
- Data acquisition systems

Absolute Maximum Ratings (Voltages to GND Unless Otherwise Stated)

Parameter		Rating	Unit
Continuous Reverse Current		20	mA
Continuous Forward Current		10	mA
Operating Junction Temperature		-40 to +150	°C
Storage Temperature		-55 to +150	°C
ESD Susceptibility			
HBM	Human Body Model	4	kV
MM	Machine Model	TBC	V
CDM	Charged Device Model	TBC	kV

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at conditions between maximum recommended operating conditions and absolute maximum ratings is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.)

Package Thermal Data

Package	θ_{JA}	P_{DIS} $T_A = +25^{\circ}C, T_J = +150^{\circ}C$
SOT23	380°C/W	330mW

Recommended Operating Conditions

Characteristic	Min	Max	Units
Reverse Current	0.06	15	mA
Operating Ambient Temperature Range	-40	+125	°C

Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

LM4040Q-2.5

Symbol	Parameter	Conditions		Typ	B Limits	C Limits	D Limits	Units
		(Note 5)	T _A					
V _{REF}	Reverse breakdown voltage	I _R = 100μA	+25°C	2.5	—	—	—	V
	Reverse breakdown voltage tolerance	I _R = 100μA	+25°C	—	±5	±12	±25	mV
			-40 to +85°C		±21	±29	±49	
-40 to +125°C	±30	±38	±63					
I _{RMIN}	Minimum operating current	—	+25°C	45	60	60	65	μA
			-40 to +85°C	—	65	65	70	
			-40 to +125°C	—	68	68	73	
ΔV _R /ΔT	Average reverse breakdown voltage temperature coefficient	I _R = 10mA	-40 to +125°C	±20	—	—	—	—
		I _R = 1mA		±15	±100	±100	±150	ppm/°C
		I _R = 100μA		±15	—	—	—	—
ΔV _R /ΔI _R	Reverse breakdown change with current	I _{RMIN} I _R < 1mA	+25°C	0.3	0.8	0.8	1.0	mV
			-40 to +85°C	—	1.0	1.0	1.2	
			-40 to +125°C	—	1.0	1.0	1.2	
		1mA < I _R < 15mA	+25°C	2.5	6.0	6.0	8.0	
			-40 to +85°C	—	8.0	8.0	10.0	
			-40 to +125°C	—	8.0	8.0	10.0	
Z _R	Dynamic output impedance	I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R		0.3	0.8	0.9	1.1	Ω
e _n	Noise voltage	I _R = 100μA, 10Hz < f < 10kHz		35	—	—	—	μV _{RMS}
V _R	Long term stability (non-cumulative)	t = 1000Hrs, I _R = 100μA		120	—	—	—	ppm
V _{HYST}	Thermal hysteresis	ΔT = -40°C to = +125°C		0.08	—	—	—	%

Electrical Characteristics (continued) (@T_A = +25°C, unless otherwise specified.)

LM4040Q-3.0

Symbol	Parameter	Conditions		Typ	B Limits	C Limits	D Limits	Units
		(Note 5)	T _A					
V _{REF}	Reverse breakdown voltage	I _R = 100μA	+25°C	3.0	—	—	—	V
	Reverse breakdown voltage tolerance	I _R = 100μA	+25°C	—	±6	±15	±30	mV
			-40 to +85°C		±26	±34	±59	
-40 to +125°C	TBD	±45	±75					
I _{RMIN}	Minimum operating current	—	+25°C	47	62	62	67	μA
			-40 to +85°C	—	67	67	72	
			-40 to +125°C	—	70	70	75	
ΔV _R /ΔT	Average reverse breakdown voltage temperature coefficient	I _R = 10mA	-40 to +125°C	±20	—	—	—	—
		I _R = 1mA		±15	±100	±100	±150	ppm/°C
		I _R = 100μA		±15	—	—	—	—
ΔV _R /ΔI _R	Reverse breakdown change with current	I _{RMIN} I _R < 1mA	+25°C	0.4	0.8	0.8	1.0	mV
			-40 to +85°C	—	1.1	1.1	1.3	
			-40 to +125°C	—	1.1	1.1	1.3	
		1mA < I _R < 15mA	+25°C	2.7	6.0	6.0	8.0	
			-40 to +85°C	—	9.0	9.0	11.0	
			-40 to +125°C	—	9.0	9.0	11.0	
Z _R	Dynamic output impedance	I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R		0.4	0.9	0.9	1.2	Ω
e _n	Noise voltage	I _R = 100μA, 10Hz < f < 10kHz		35	—	—	—	μV _{RMS}
V _R	Long term stability (non-cumulative)	t = 1000Hrs, I _R = 100μA		120	—	—	—	ppm
V _{HYST}	Thermal hysteresis	ΔT = -40°C to = +125°C		0.08	—	—	—	%

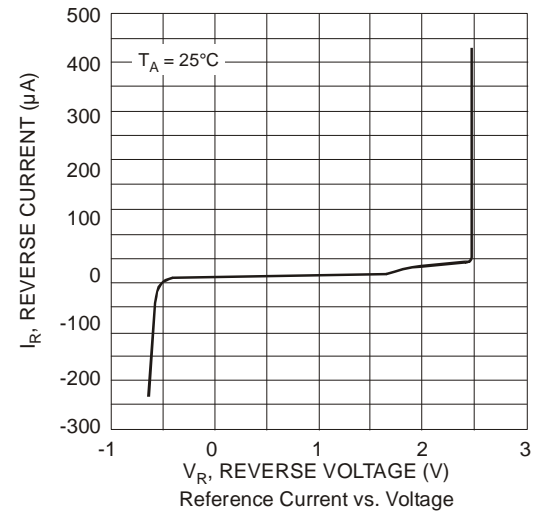
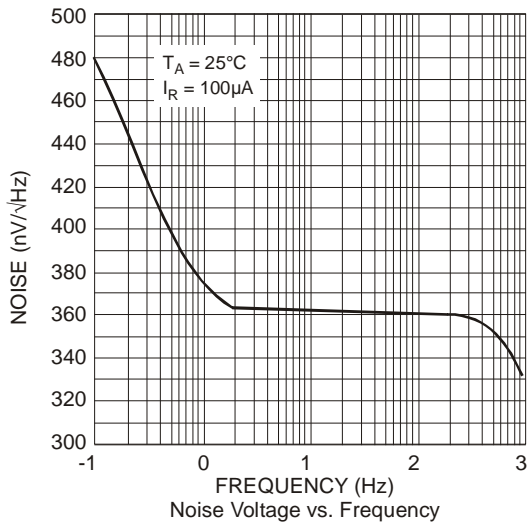
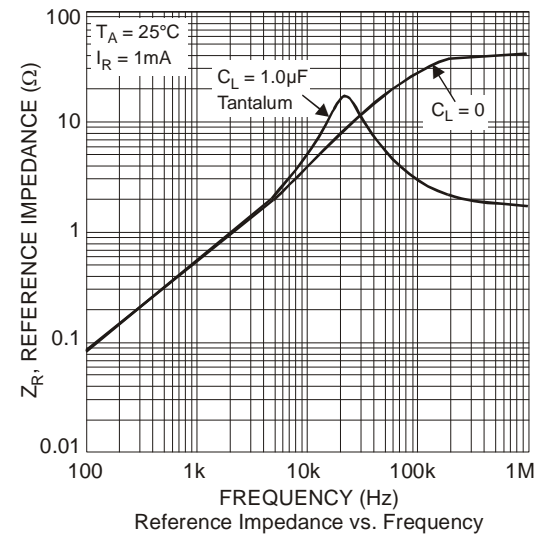
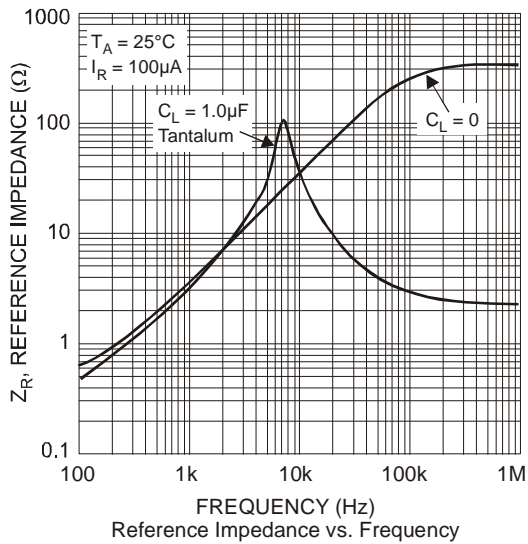
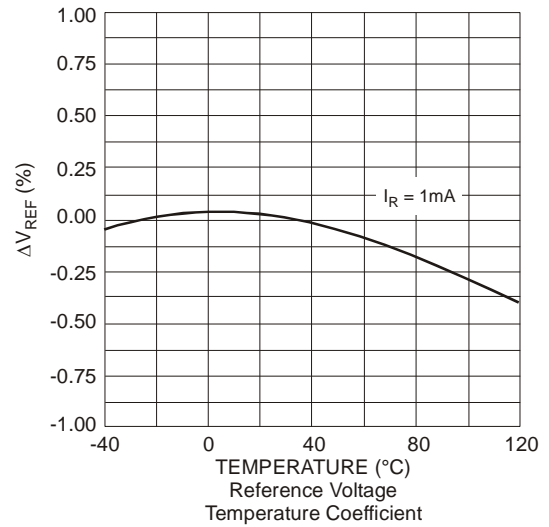
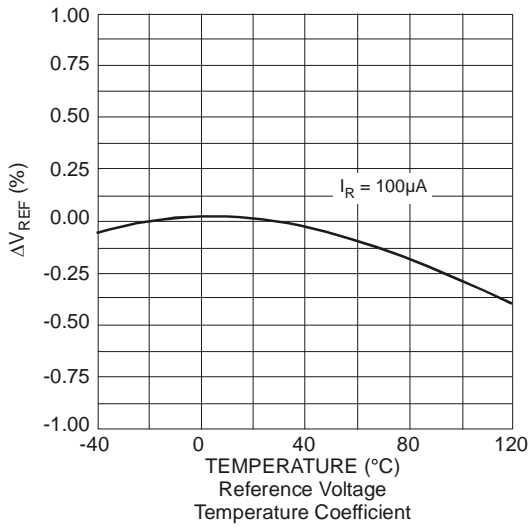
Electrical Characteristics (cont.) (@T_A = +25°C, unless otherwise specified.)

LM4040Q-5.0

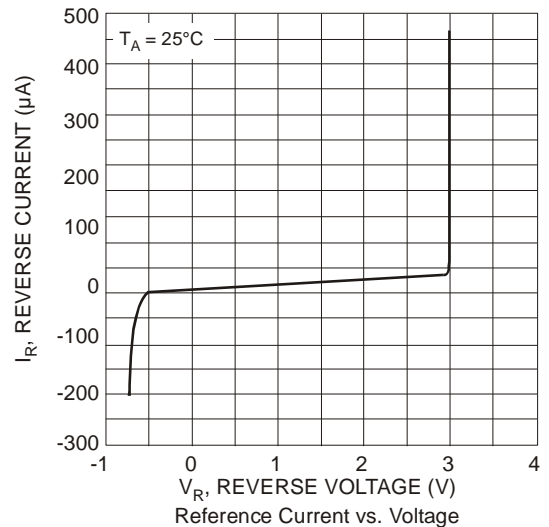
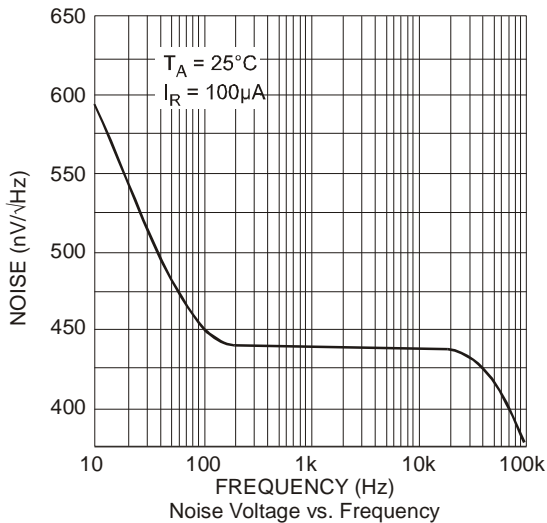
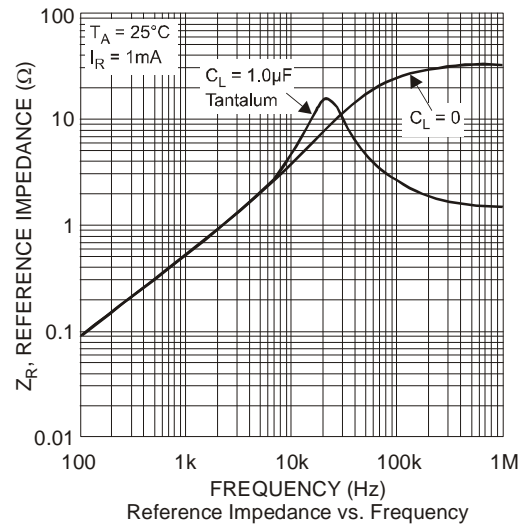
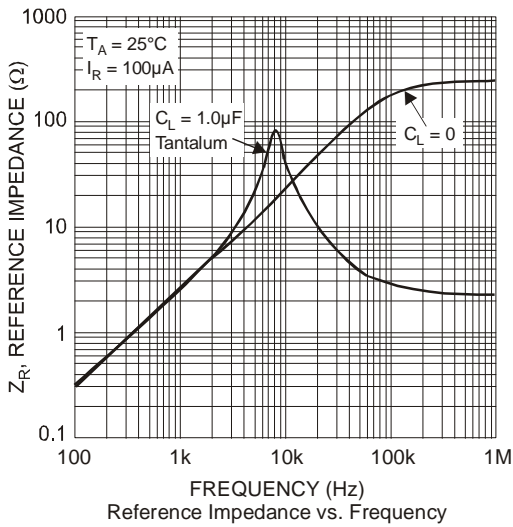
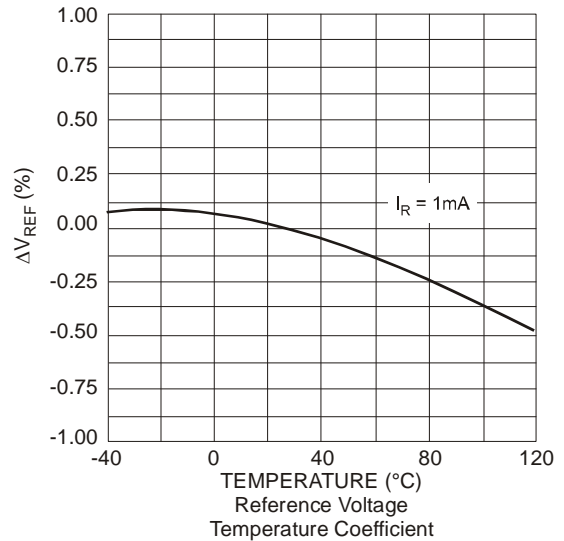
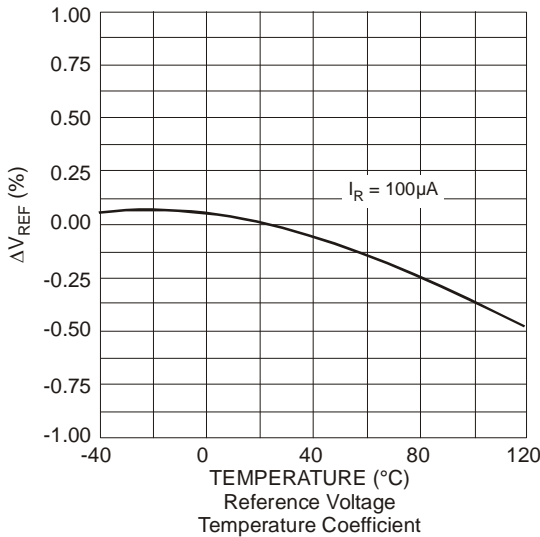
Symbol	Parameter	Conditions		Typ	B Limits	C Limits	D Limits	Units
		(Note 5)	T _A					
V _{REF}	Reverse breakdown voltage	I _R = 100μA	+25°C	5.0	—	—	—	V
	Reverse breakdown voltage tolerance	I _R = 100μA	+25°C	—	±10	±25	±50	mV
			-40 to +85°C		±43	±58	±99	
-40 to +125°C	±60	±75	±125					
I _{RMIN}	Minimum operating current	—	+25°C	54	74	74	79	μA
			-40 to +85°C	—	80	80	85	
			-40 to +125°C	—	83	83	88	
ΔV _R /ΔT	Average reverse breakdown voltage temperature coefficient	I _R = 10mA	-40 to +125°C	±30	—	—	—	—
		I _R = 1mA		±20	±100	±100	±150	ppm/°C
		I _R = 100μA		±20	—	—	—	—
ΔV _R /ΔI _R	Reverse breakdown change with current	I _{RMIN} I _R < 1mA	+25°C	0.5	1.0	1.0	1.3	mV
			-40 to +85°C	—	1.4	1.4	1.8	
			-40 to +125°C	—	1.4	1.4	1.8	
		1mA < I _R < 15mA	+25°C	3.5	8.0	8.0	10.0	
			-40 to +85°C	—	12.0	12.0	15.0	
			-40 to +125°C	—	12.0	12.0	15.0	
Z _R	Dynamic output impedance	I _R = 1mA, f = 120Hz I _{AC} = 0.1I _R		0.5	1.1	1.1	1.5	Ω
e _n	Noise voltage	I _R = 100μA 10Hz < f < 10kHz		80	—	—	—	μV _{RMS}
V _R	Long term stability (non-cumulative)	t = 1000Hrs, I _R = 100μA		120	—	—	—	ppm
V _{HYST}	Thermal hysteresis	ΔT = -40°C to = +125°C		0.08	—	—	—	%

Note: 5. Unless otherwise stated, voltages specified are relative to the ANODE pin.

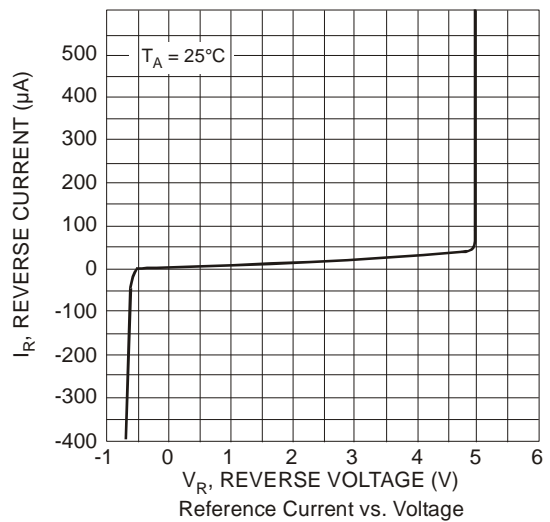
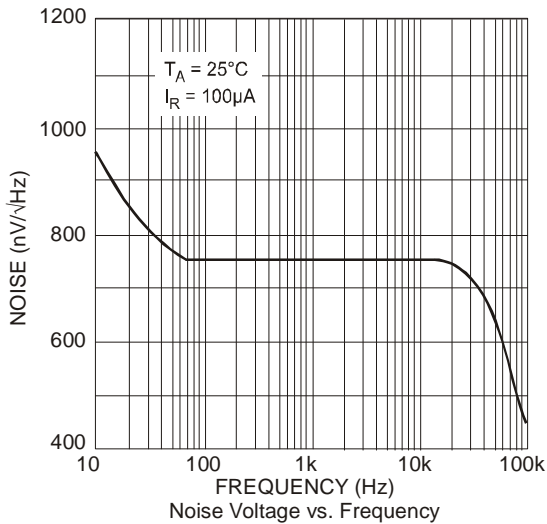
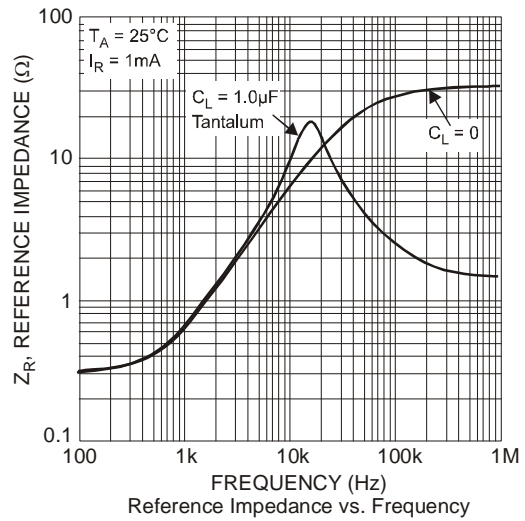
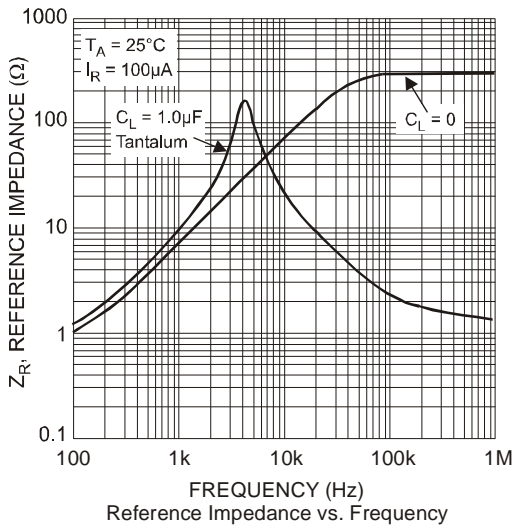
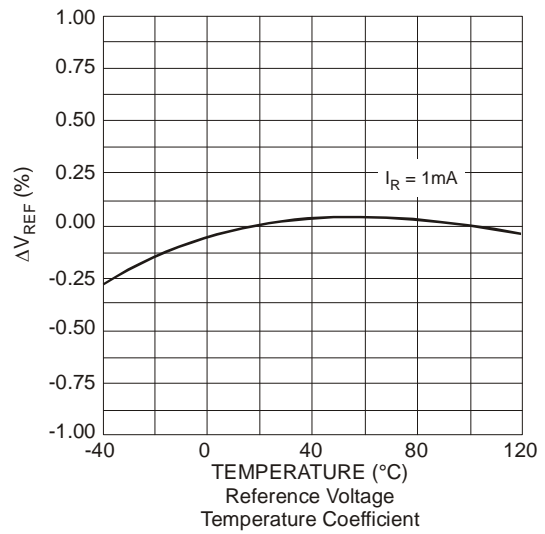
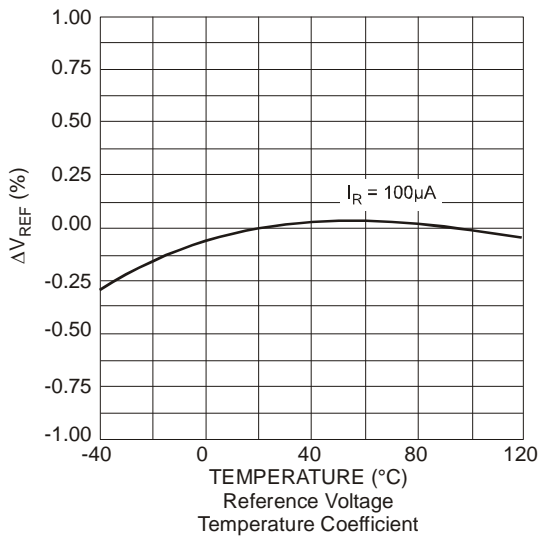
Typical Characteristics LM4040Q-2.5



Typical Characteristics LM4040Q-3.0

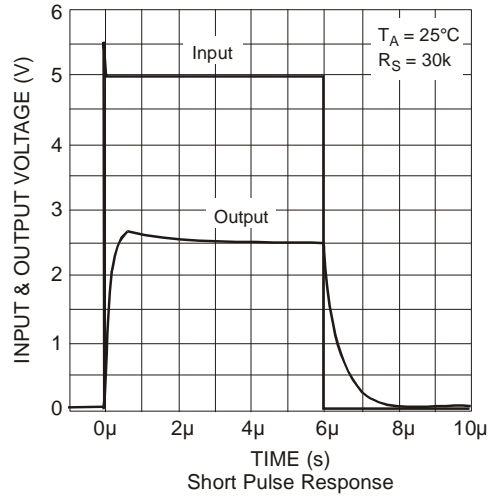
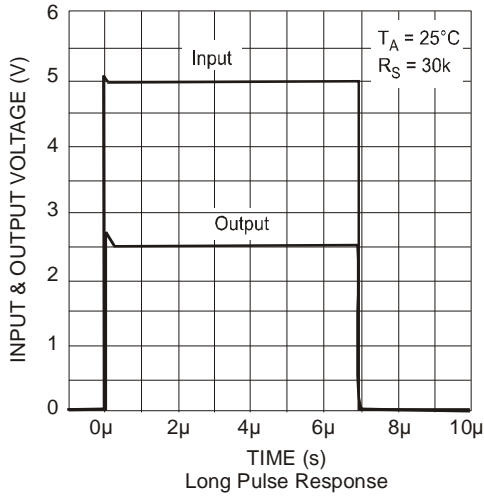


Typical Characteristics LM4040Q-5.0

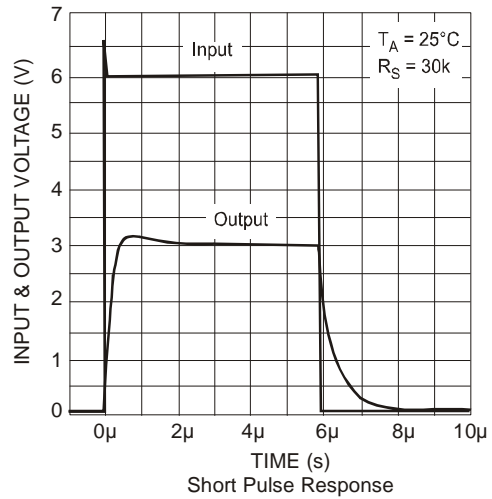
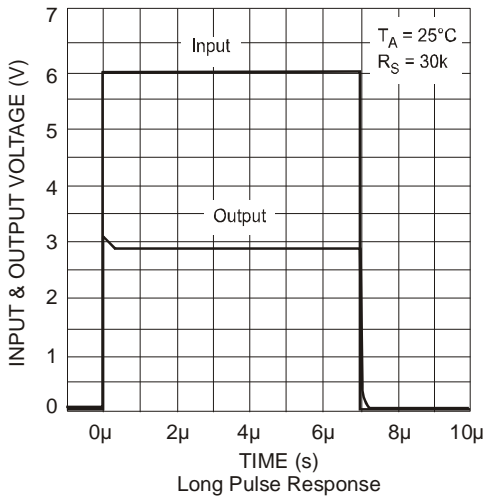


Start-Up Characteristics LM4040Q-2.5, 3.0 and 5.0

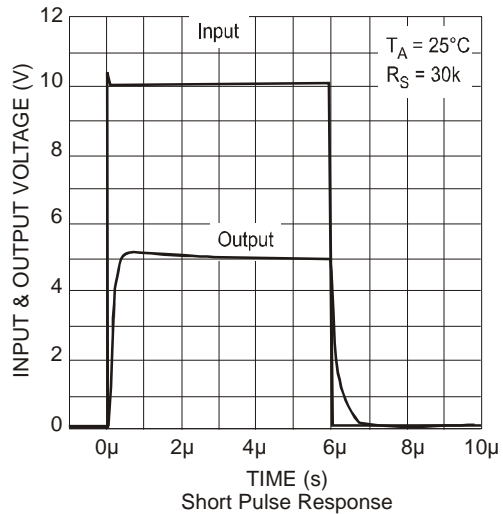
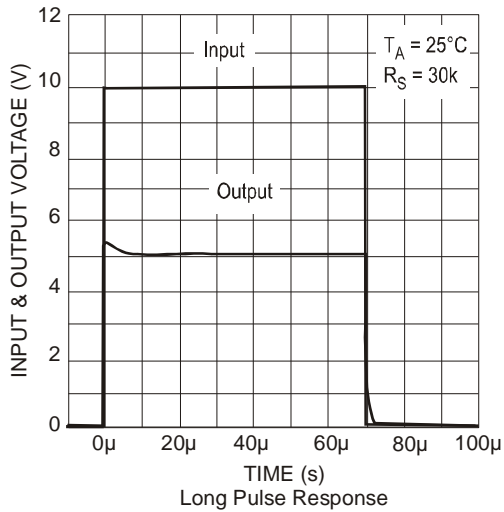
LM4040-2.5



LM4040-3.0



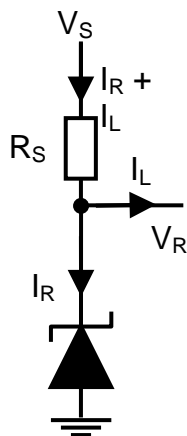
LM4040-5.0



Application Information

In a conventional shunt regulator application (*Figure 1*), an external series resistor (R_S) is connected between the supply voltage, V_S , and the LM4040.

R_S determines the current that flows through the load (I_L) and the LM4040 (I_R). Since load current and supply voltage may vary, R_S should be small enough to supply at least the minimum acceptable I_R to the LM4040 even when the supply voltage is at its minimum and the load current is at its maximum value. When the supply voltage is at its maximum and I_L is at its minimum, R_S should be large enough so that the current flowing through the LM4040 is less than 15 mA.



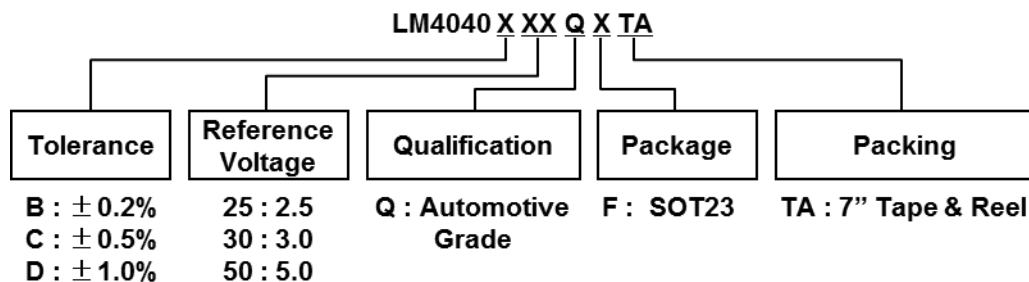
R_S is determined by the supply voltage, (V_S), the load and operating current, (I_L and I_R), and the LM4040's reverse breakdown voltage, V_R .

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

Printed circuit board layout considerations

LM4040Qs in the SOT23 package have the die attached to pin 1, which results in an electrical contact between pin 2 and pin 3. Therefore, pin 1 of the SOT-23 package must be left floating or connected to pin 2.

Ordering Information

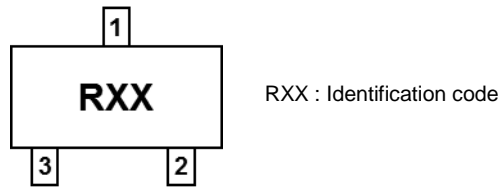


Order Code	+25°C Tol	Voltage (V)	Package (Note 6)	Package Code	Identification Code	Packing: 7" Tape and Reel			Qualification Grade (Note 7)
						Quantity	Tape Width	Part Number Suffix	
LM4040B25QFTA	0.2%	2.5	SOT23	F	R2B	3,000	8mm	TA	Automotive Grade
LM4040B30QFTA		3.0	SOT23	F	R3B	3,000	8mm	TA	Automotive Grade
LM4040B50QFTA		5.0	SOT23	F	R5B	3,000	8mm	TA	Automotive Grade
LM4040C25QFTA	0.5%	2.5	SOT23	F	R2C	3,000	8mm	TA	Automotive Grade
LM4040C30QFTA		3.0	SOT23	F	R3C	3,000	8mm	TA	Automotive Grade
LM4040C50QFTA		5.0	SOT23	F	R5C	3,000	8mm	TA	Automotive Grade
LM4040D25QFTA	1%	2.5	SOT23	F	R2D	3,000	8mm	TA	Automotive Grade
LM4040D30QFTA		3.0	SOT23	F	R3D	3,000	8mm	TA	Automotive Grade
LM4040D50QFTA		5.0	SOT23	F	R5D	3,000	8mm	TA	Automotive Grade

Note: 6. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>.

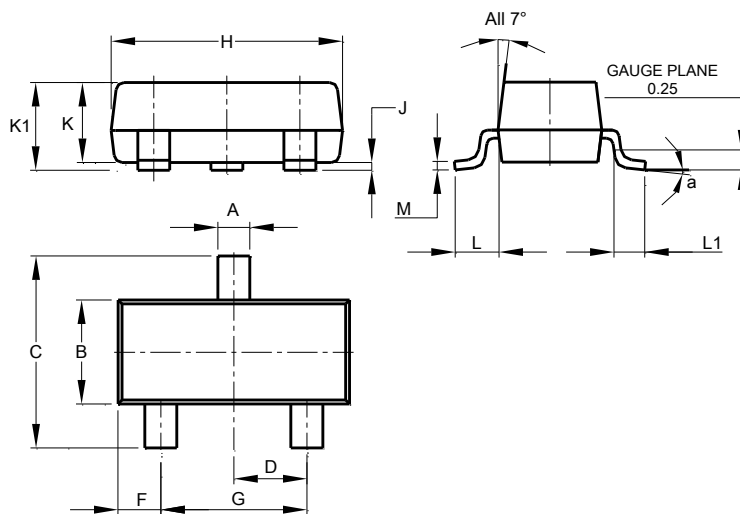
7. LM4040Q is classified as "Automotive Grade" and supports PPAP documentation. See LM4040 datasheet for commercial qualified versions.

Marking Information



Package Outline Dimensions

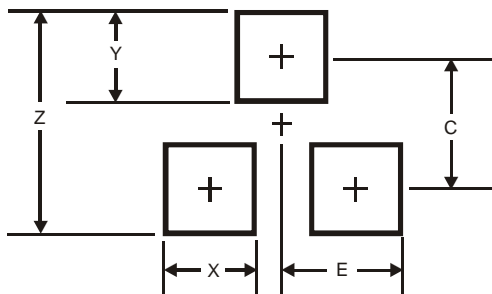
Please see AP02002 at <http://www.diodes.com/datasheets/ap02002.pdf> for the latest version.



SOT23			
Dim	Min	Max	Typ
A	0.37	0.51	0.40
B	1.20	1.40	1.30
C	2.30	2.50	2.40
D	0.89	1.03	0.915
F	0.45	0.60	0.535
G	1.78	2.05	1.83
H	2.80	3.00	2.90
J	0.013	0.10	0.05
K	0.890	1.00	0.975
K1	0.903	1.10	1.025
L	0.45	0.61	0.55
L1	0.25	0.55	0.40
M	0.085	0.150	0.110
a	8°		
All Dimensions in mm			

Suggested Pad Layout

Please see AP02001 at <http://www.diodes.com/datasheets/ap02001.pdf> for the latest version.



Dimensions	Value (in mm)
Z	2.9
X	0.8
Y	0.9
C	2.0
E	1.35

IMPORTANT NOTICE

DIODES INCORPORATED MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

Diodes Incorporated and its subsidiaries reserve the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. Diodes Incorporated does not assume any liability arising out of the application or use of this document or any product described herein; neither does Diodes Incorporated convey any license under its patent or trademark rights, nor the rights of others. Any Customer or user of this document or products described herein in such applications shall assume all risks of such use and will agree to hold Diodes Incorporated and all the companies whose products are represented on Diodes Incorporated website, harmless against all damages.

Diodes Incorporated does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel.

Should Customers purchase or use Diodes Incorporated products for any unintended or unauthorized application, Customers shall indemnify and hold Diodes Incorporated and its representatives harmless against all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized application.

Products described herein may be covered by one or more United States, international or foreign patents pending. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks.

This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes Incorporated.

LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

- A. Life support devices or systems are devices or systems which:
 - 1. are intended to implant into the body, or
 - 2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.
- B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

Copyright © 2015, Diodes Incorporated

www.diodes.com