AUTOMOTIVE GRADE PRECISION MICROPOWER SHUNT VOLTAGE REFERENCES

Description

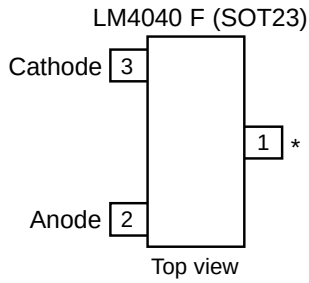
The LM4040Q is a family of bandgap circuits designed to achieve precision micro-power voltage references of 2.5V, 3.0V and 5.0V. The devices are available in 0.2% B-grade, 0.5% C-grade and 1% D-grade initial tolerances.

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

Pin Assignments



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

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... 45µV_{RMS}
- 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)**

Applications

- Automotive reference voltage
- Data acquisition systems

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/.

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°C, T_J = +150°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 (Note 5)	Conditions T_A	Typ	B Limits	C Limits	D Limits	Units
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	
$\Delta V_R/\Delta T$	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	—	—	—	—
$\Delta V_R/\Delta I_R$	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 (Note 5)	Conditions T_A	Typ	B Limits	C Limits	D Limits	Units
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	
$\Delta V_R/\Delta T$	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	—	—	—	—
$\Delta V_R/\Delta I_R$	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	—	—	—	%

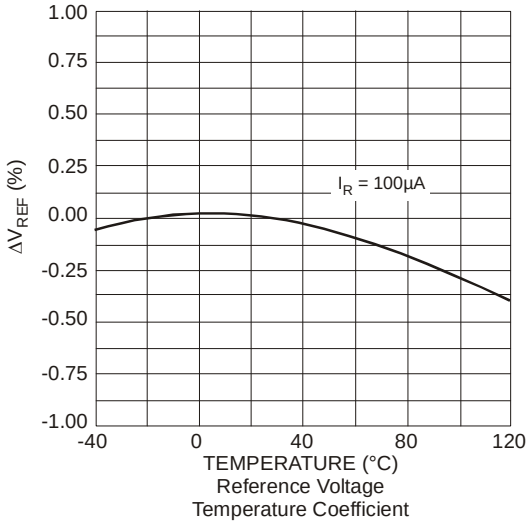
Electrical Characteristics (cont.) (@T_A = +25°C, unless otherwise specified.)

LM4040Q-5.0

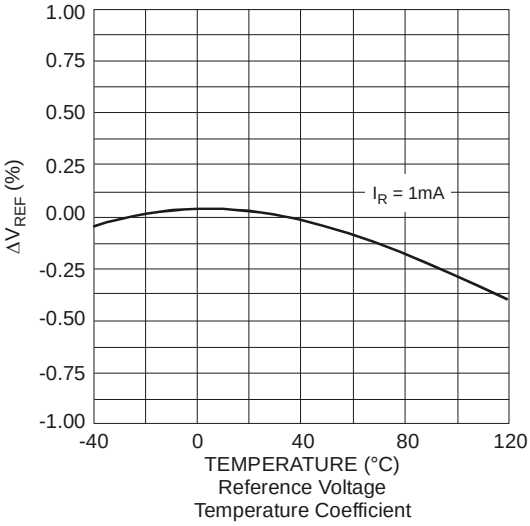
Symbol	Parameter	Conditions (Note 5)	Conditions T_A	Typ	B Limits	C Limits	D Limits	Units
V_{REF}	Reverse breakdown voltage	I_R = 100µA	+25°C	5.0	—	—	—	V
	Reverse breakdown voltage tolerance	I_R = 100µA	+25°C	—	±10	±25	±50	mV
			-40 to +85°C		±43	±58	±99	
			-40 to +125°C		±60	±75	±125	
I_{RMIN}	Minimum operating current	—	+25°C	54	74	74	79	µA
			-40 to +85°C	—	80	80	85	
			-40 to +125°C		83	83	88	
$\Delta V_R/\Delta T$	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	—	—	—	—
$\Delta V_R/\Delta I_R$	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}	Themal hysteresis	ΔT = -40°C to = +125°C		0.08	—	—	—	%

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

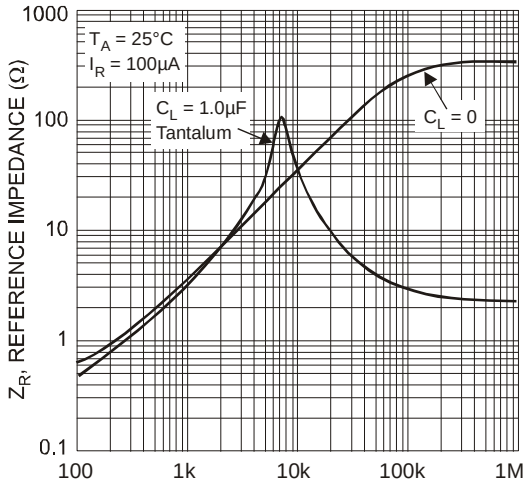
Typical Characteristics LM4040Q-2.5



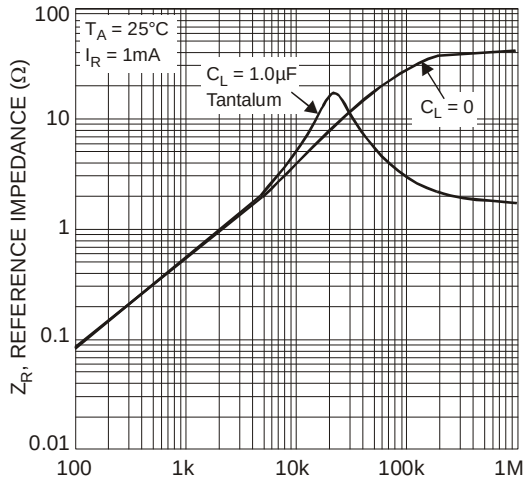
Reference Voltage Temperature Coefficient



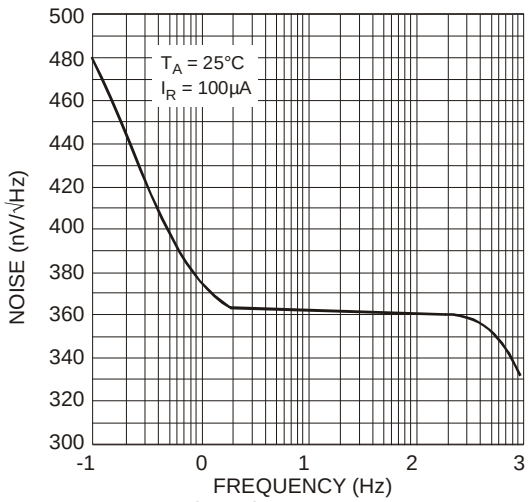
Reference Voltage Temperature Coefficient



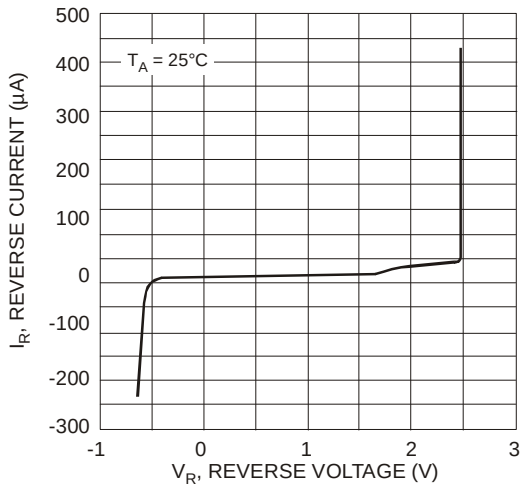
Reference Impedance vs. Frequency



Reference Impedance vs. Frequency

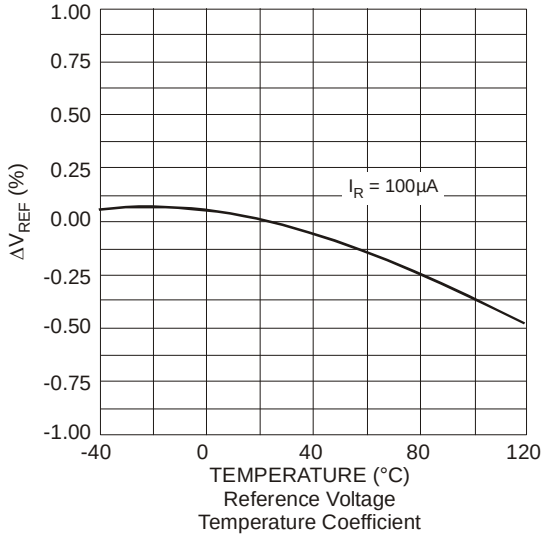


Noise Voltage vs. Frequency

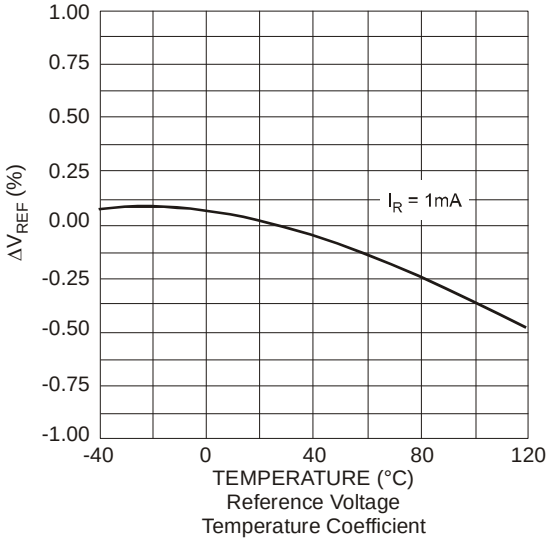


Reference Current vs. Voltage

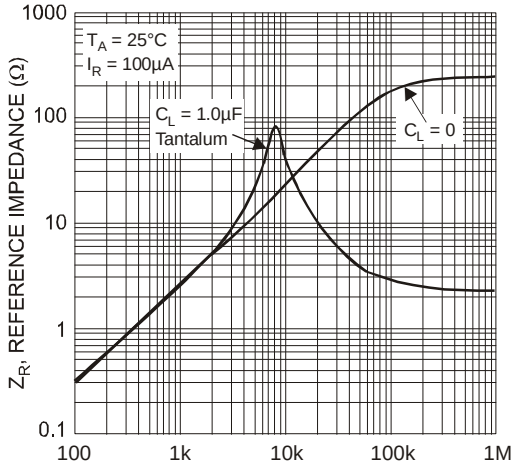
Typical Characteristics LM4040Q-3.0



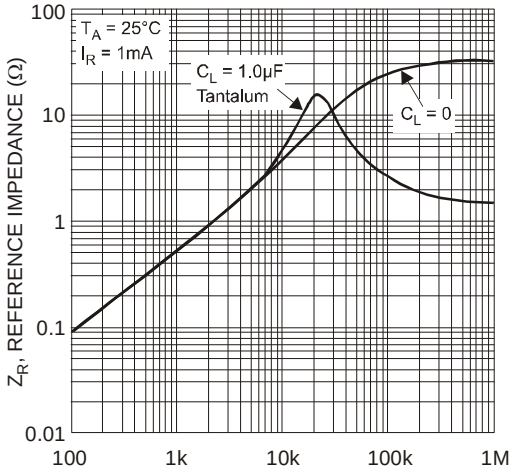
Reference Voltage Temperature Coefficient



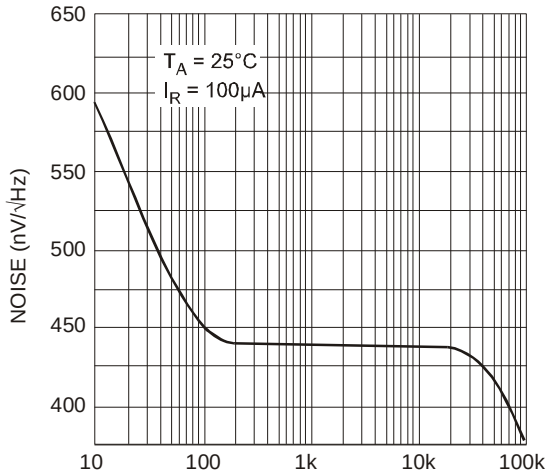
Reference Voltage Temperature Coefficient



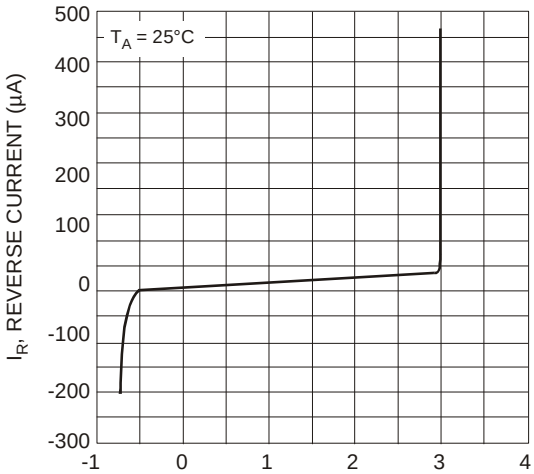
Reference Impedance vs. Frequency



Reference Impedance vs. Frequency

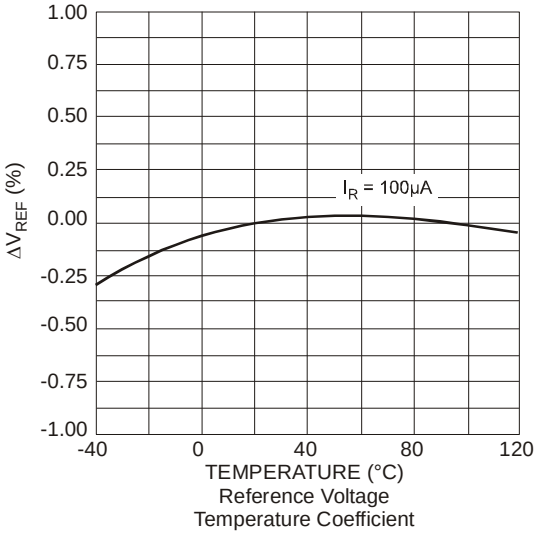


Noise Voltage vs. Frequency

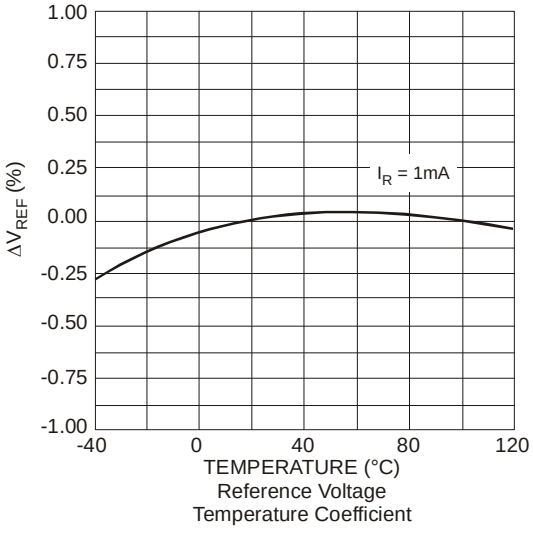


Reference Current vs. Voltage

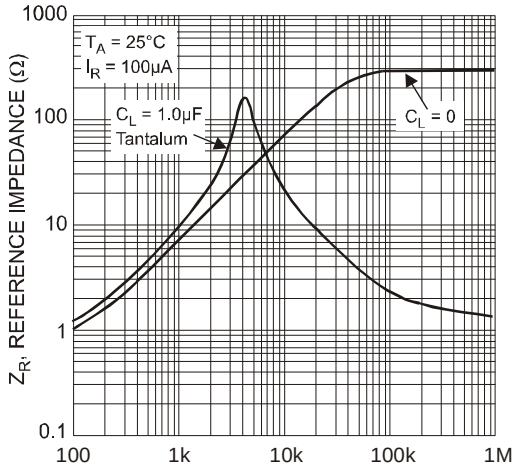
Typical Characteristics LM4040Q-5.0



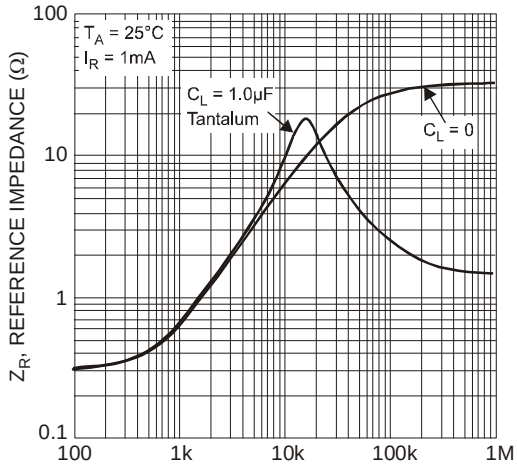
Reference Voltage Temperature Coefficient



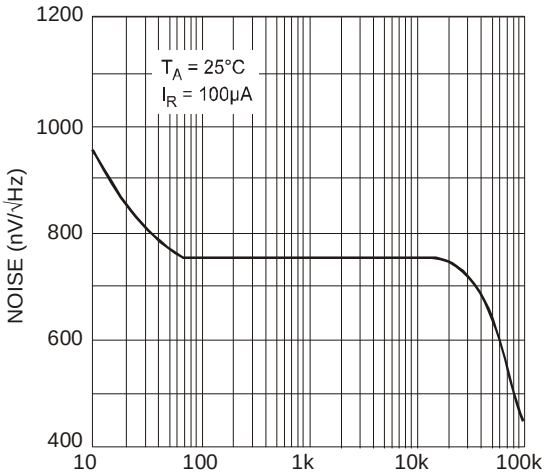
Reference Voltage Temperature Coefficient



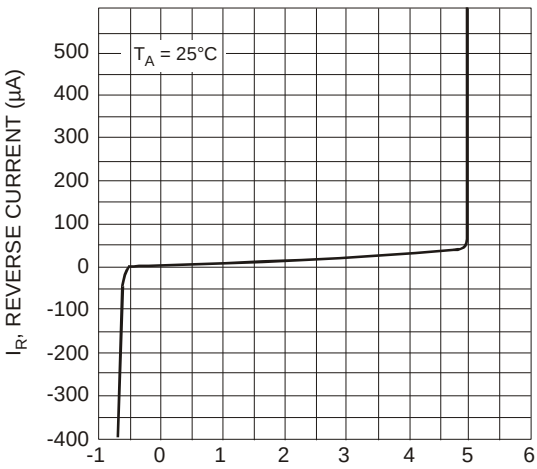
Reference Impedance vs. Frequency



Reference Impedance vs. Frequency



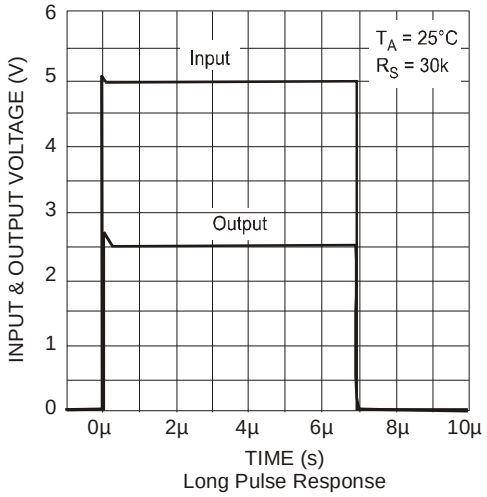
Noise Voltage vs. Frequency



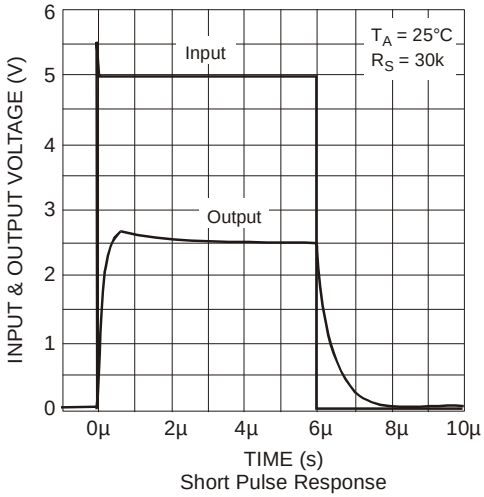
Reference Current vs. Voltage

Start-Up Characteristics LM4040Q-2.5, 3.0 and 5.0

LM4040-2.5

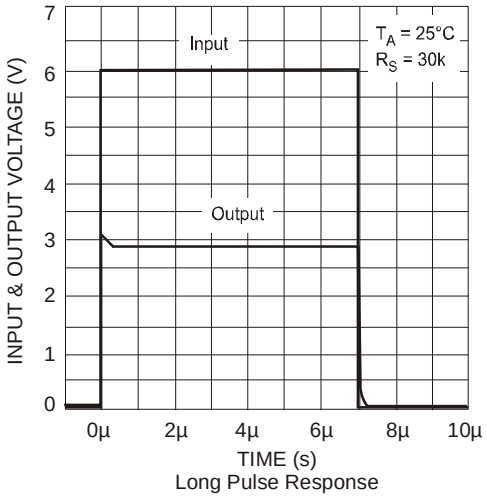


Long Pulse Response

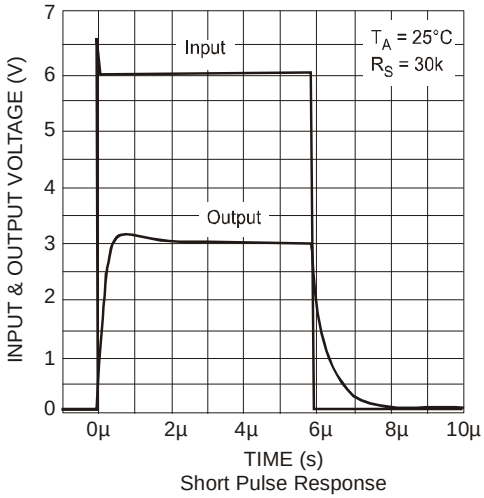


Short Pulse Response

LM4040-3.0

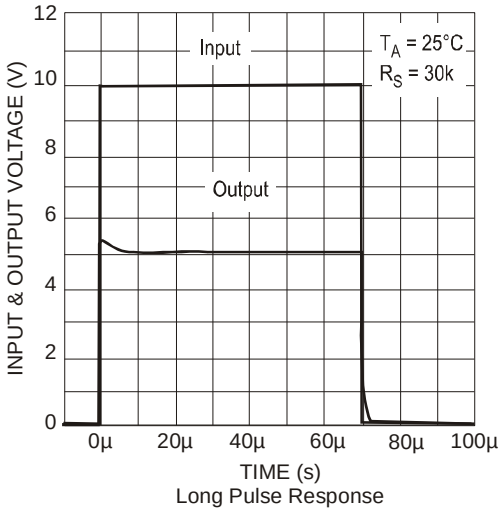


Long Pulse Response

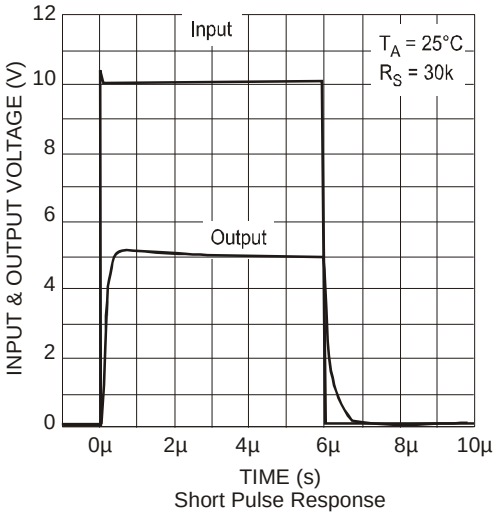


Short Pulse Response

LM4040-5.0



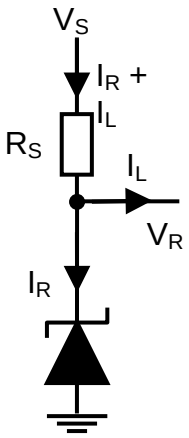
Long Pulse Response



Short Pulse Response

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.

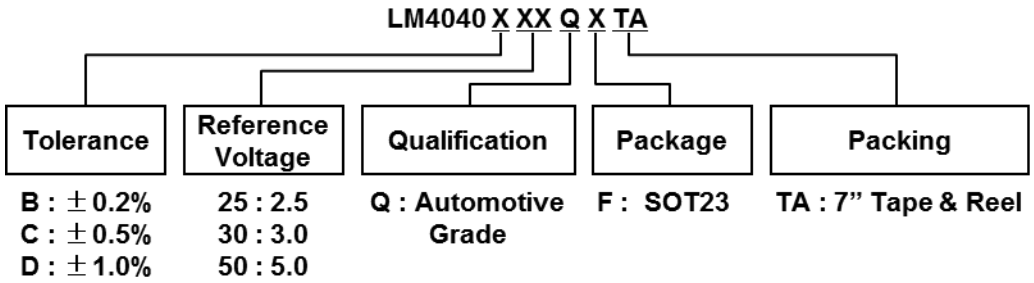
R_S is determined by the supply voltage, (V_S), the load and operating current, (I_L and I_R), and the LM4040's reverse breakdown voltage, V_R.

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

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.

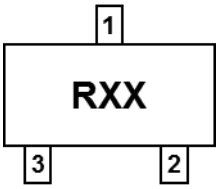
Ordering Information



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.

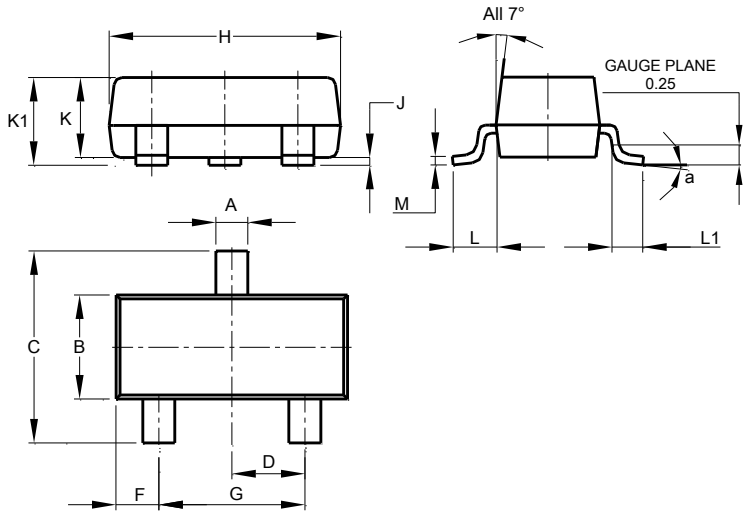
Marking Information



RXX : Identification code

Package Outline Dimensions

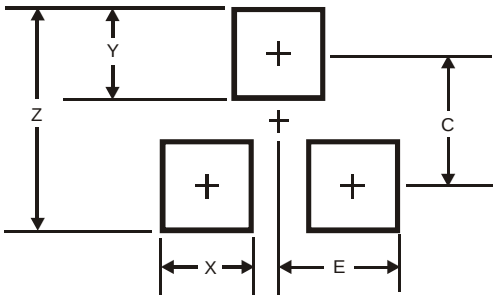
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.



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

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