AUTOMOTIVE COMPLIANT PRECISION MICROPOWER SHUNT VOLTAGE REFERENCES

Description

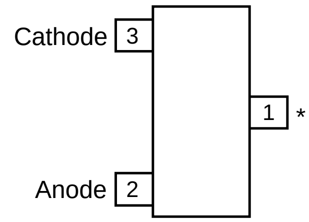
The LM4040Q is a family of bandgap circuits designed to achieve precision micropower voltage references of 2.5V, 3.0V, 3.3V, 4.096V, and 5.0V. The devices are available in 0.2% B-grade, 0.5% C-grade, and 1% D-grade initial tolerances.

The devices 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 is designed to be highly tolerant of capacitive loads that maintain excellent stability.

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

Pin Assignments

(Top View)



SOT23

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

Features

- Small Package: 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 of 60µA to 15mA
- Extended Temperature Range of -40°C to +125°C
- Low Temperature Coefficient of 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)**
- **The LM4040Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities.** **https://www.diodes.com/quality/product-definitions/**

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) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ 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.

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
CDM	Charged Device Model	1	kV

Caution: Stresses greater than the *Absolute Maximum Ratings* specified above can 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 can be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and can 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	Unit
Reverse Current	0.06	15	mA
Operating Ambient Temperature Range	-40	+125	°C

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

LM4040-25Q

Symbol	Parameter	Conditions (Note 4)	Conditions T_A	Typ	B Limits	C Limits	D Limits	Unit
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	—	—	—	ppm/°C
		I_R = 1mA		±15	±100	±100	±150	
		I_R = 100µA		±15	—	—	—	
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Current	$I_{RMIN} \le I_R \le$ 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 $\le I_R \le$ 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	—	—	—	%

Note: 4. Unless otherwise stated, voltages specified are relative to the Anode pin.

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

LM4040-30Q

Symbol	Parameter	Conditions (Note 4)	T_A	Typ	B Limits	C Limits	D Limits	Unit
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		±36	±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	—	—	—	ppm/°C
		I_R = 1mA		±15	±100	±100	±150	
		I_R = 100µA		±15	—	—	—	
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Current	$I_{RMIN} \le I_R \le$ 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 $\le I_R \le$ 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	—	—	—	%

LM4040-33Q

Symbol	Parameter	Conditions (Note 4)	T_A	Typ	B Limits	C Limits	D Limits	Unit
V_{REF}	Reverse Breakdown Voltage	I_R = 100µA	+25°C	3.3	—	—	—	V
	Reverse Breakdown Voltage Tolerance	I_R = 100µA	+25°C	—	±6.6	±16.5	±33	mV
			-40 to +85°C		±28	±38	±65	
			-40 to +125°C		±40	±50	±83	
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	—	—	—	ppm/°C
		I_R = 1mA		±15	±100	±100	±150	
		I_R = 100µA		±15	—	—	—	
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Current	$I_{RMIN} \le I_R \le$ 1mA	+25°C	0.4	0.8	0.8	1	mV
			-40 to +85°C	—	1.1	1.1	1.3	
			-40 to +125°C		1.1	1.1	1.3	
		1mA $\le I_R \le$ 15mA	+25°C	2.7	6	6	8	
			-40 to +85°C	—	9.0	9	11	
			-40 to +125°C		9.0	9	11	
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	—	—	—	%

Note: 4. Unless otherwise stated, voltages specified are relative to the Anode pin.

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

LM4040-41Q

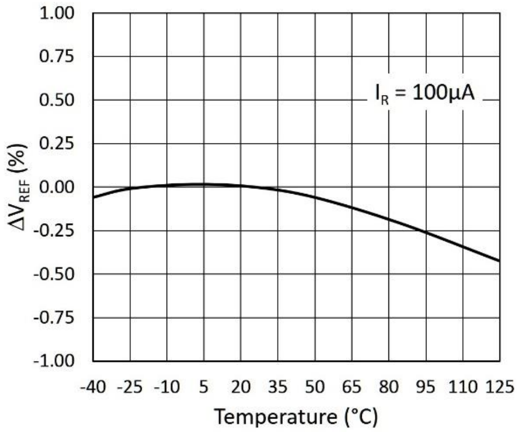
Symbol	Parameter	Conditions		Typ	B Limits	C Limits	D Limits	Unit
		(Note 4)	T_A					
V_{REF}	Reverse Breakdown Voltage	I_R = 100µA	+25°C	4.096	—	—	—	V
	Reverse Breakdown Voltage Tolerance	I_R = 100µA	+25°C	—	±8.2	±20	±41	mV
			-40 to +85°C		±35	±47	±81	
			-40 to +125°C		±49	±60	±102	
I_{RMIN}	Minimum Operating Current	—	+25°C	50	83	83	83	µA
			-40 to +85°C	—	88	88	88	
			-40 to +125°C		88	88	88	
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 10mA	-40 to +125°C	±30	—	—	—	ppm/°C
		I_R = 1mA		±20	±100	±100	±150	
		I_R = 100µA		±20	—	—	—	
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change With Current	$I_{RMIN} \leq I_R \leq$ 1mA	+25°C	0.5	0.9	0.9	1.2	mV
			-40 to +85°C	—	1.2	1.2	1.5	
			-40 to +125°C		1.2	1.2	1.5	
		1mA $\leq I_R \leq$ 15mA	+25°C	3	7	7	9	
			-40 to +85°C	—	10	10	13	
			-40 to +125°C		10	10	13	
Z_R	Dynamic Output Impedance	I_R = 1mA, f = 120Hz, I_{AC} = 0.1I_R		0.5	1	1	1.3	Ω
e_n	Noise Voltage	I_R = 100µA, 10Hz < f < 10kHz		64	—	—	—	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	80	—	—	%

LM4040-50Q

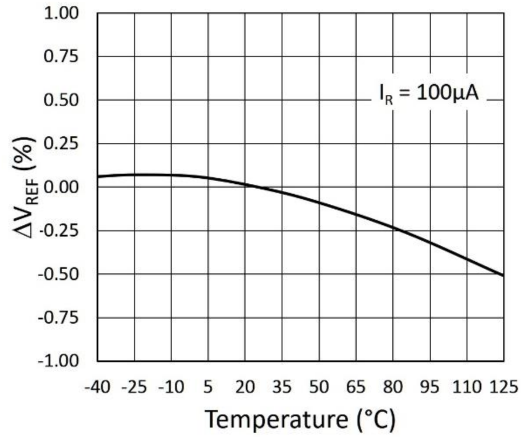
Symbol	Parameter	Conditions		Typ	B Limits	C Limits	D Limits	Unit
		(Note 4)	T_A					
V_{REF}	Reverse Breakdown Voltage	I_R = 100µA	+25°C	5.0	—	—	—	V
	Reverse Breakdown Voltage Tolerance	I_R = 100µA	+25°C	—	±10	±25	±50	mV
			-40 to +85°C		±43	±58	±99	
			-40 to +125°C		±60	±75	±125	
I_{RMIN}	Minimum Operating Current	—	+25°C	54	74	74	79	µA
			-40 to +85°C	—	80	80	85	
			-40 to +125°C		83	83	88	
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 10mA	-40 to +125°C	±30	—	—	—	ppm/°C
		I_R = 1mA		±20	±100	±100	±150	
		I_R = 100µA		±20	—	—	—	
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change With Current	$I_{RMIN} \leq I_R \leq$ 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 $\leq I_R \leq$ 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: 4. Unless otherwise stated, voltages specified are relative to the Anode pin.

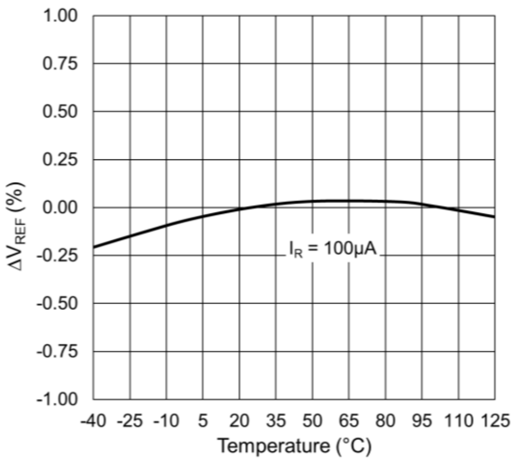
Typical Characteristics – Reference Voltage Temperature Coefficient at 100µA



LM4040-25Q



LM4040-30Q



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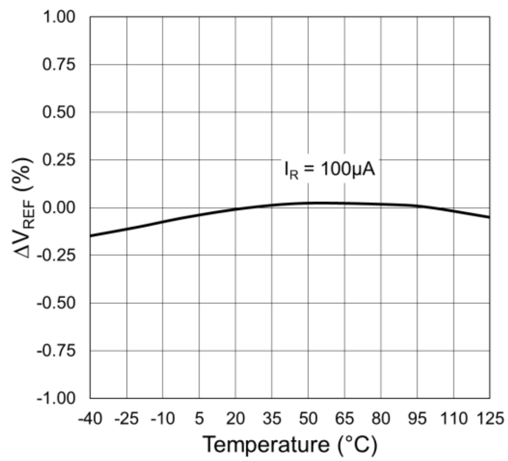

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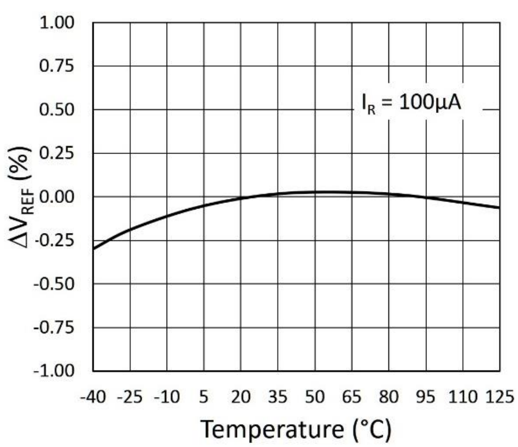
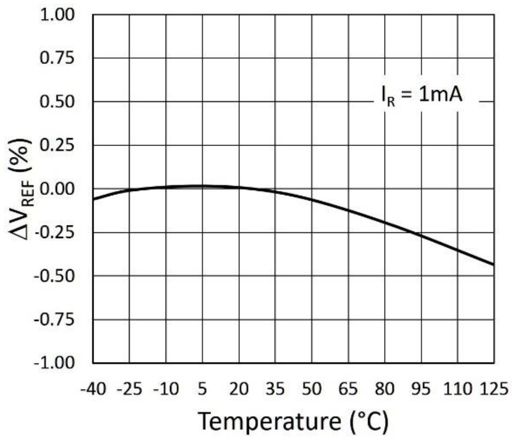


LM4040-50Q

Typical Characteristics – Reference Voltage Temperature Coefficient at 1mA



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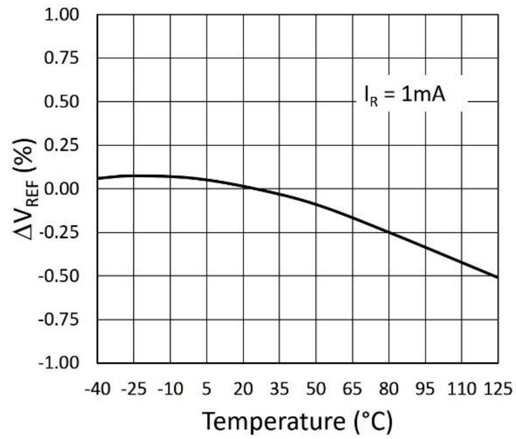

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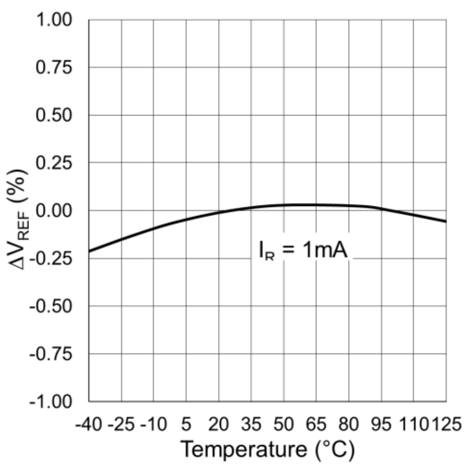

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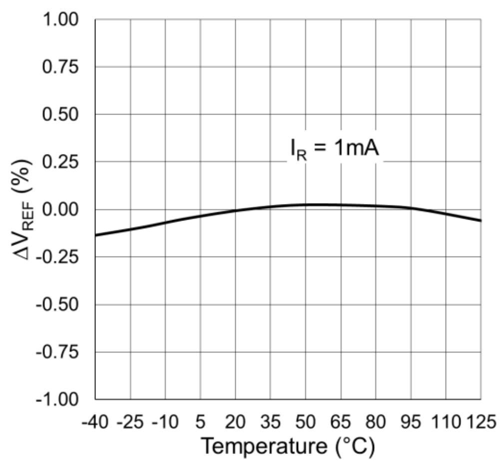

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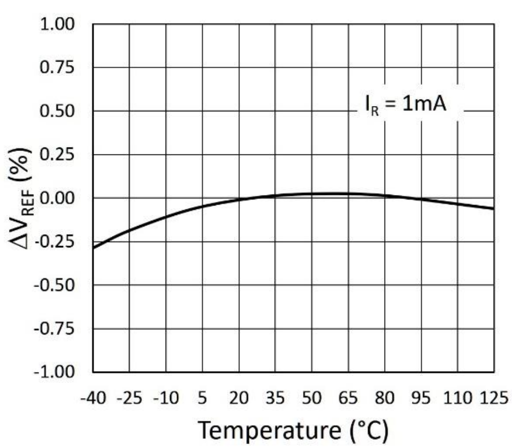
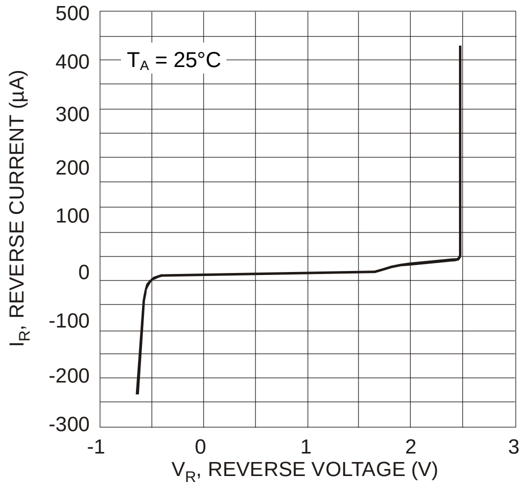
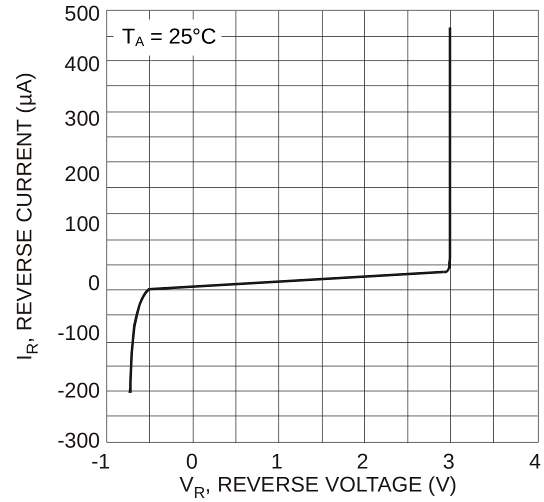


LM4040-50Q

Typical Characteristics – Reverse Characteristics



LM4040-25Q



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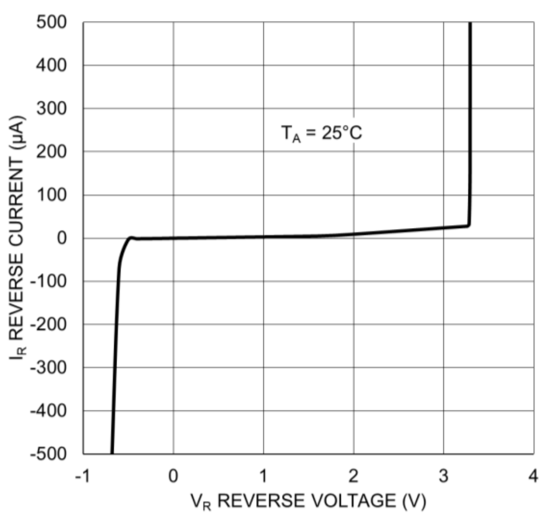

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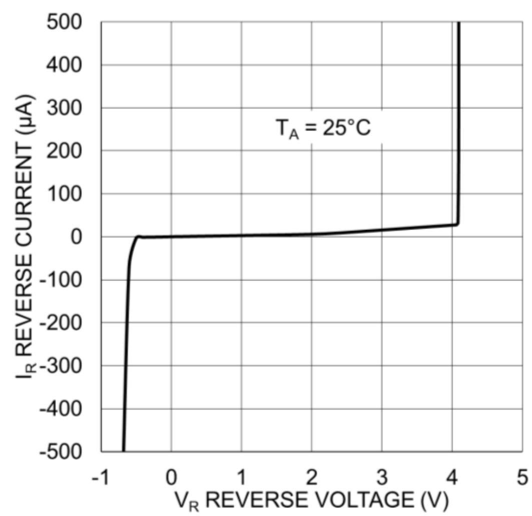

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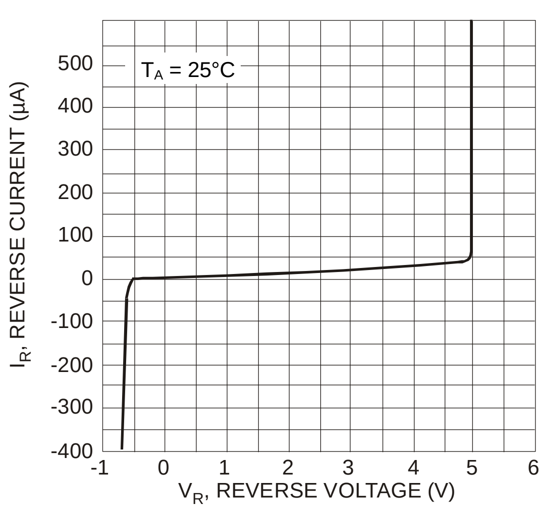
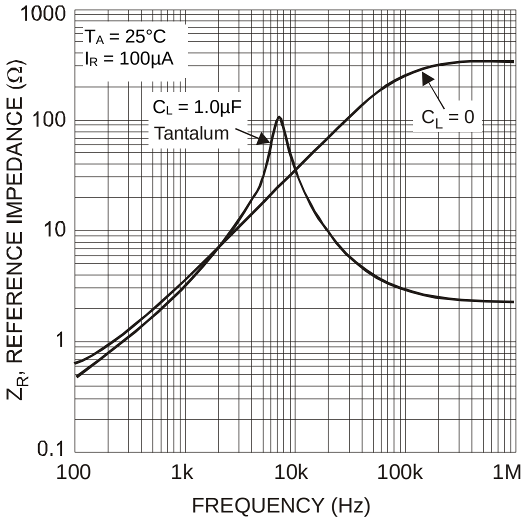
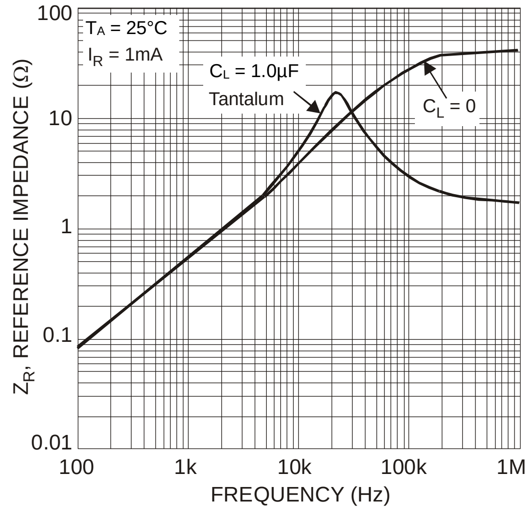


LM4040-50Q

Typical Characteristics – LM4040Q Reference Impedance



LM4040-25Q



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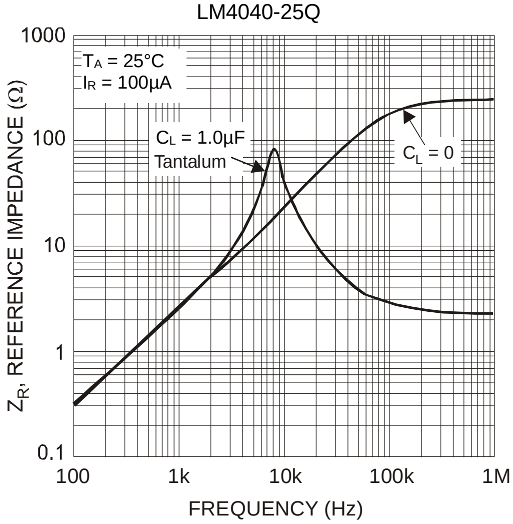
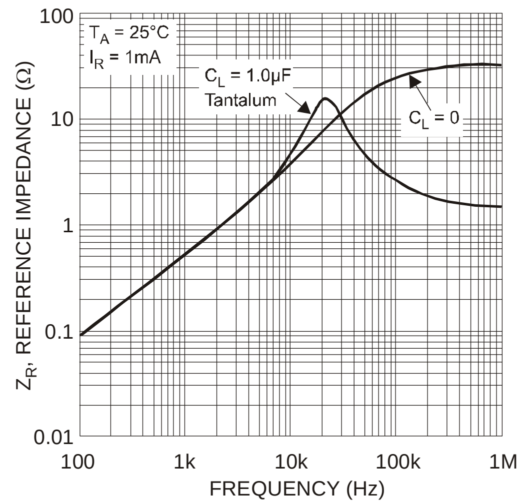
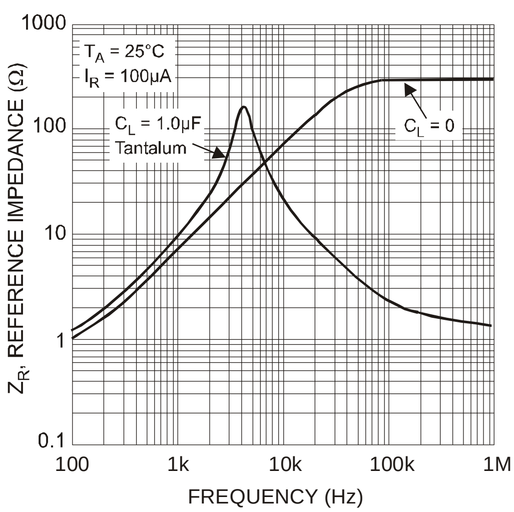


LM4040-30Q



LM4040-30Q



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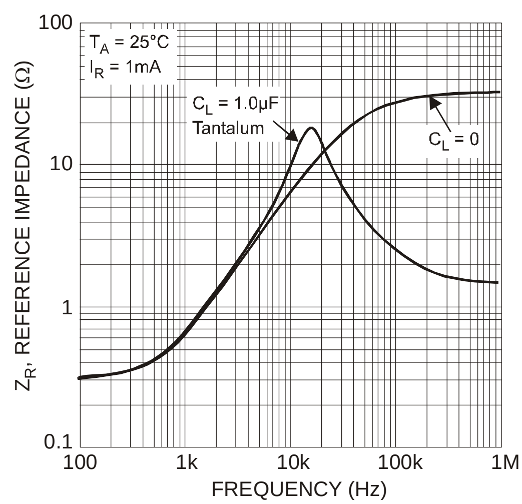
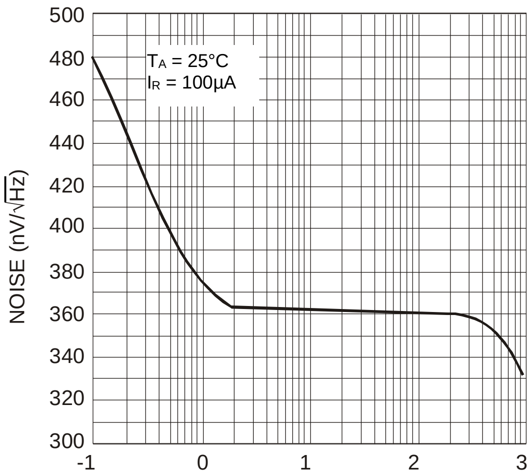
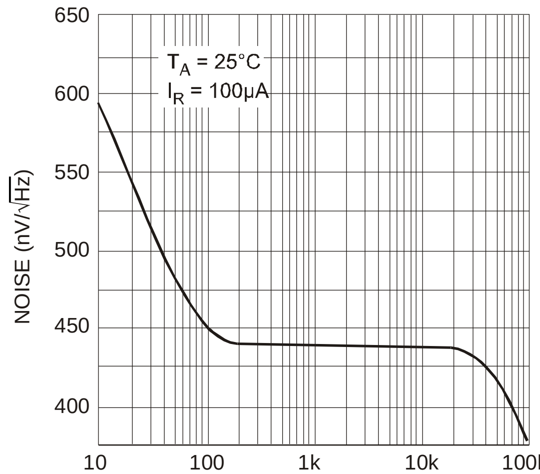


LM4040-50Q

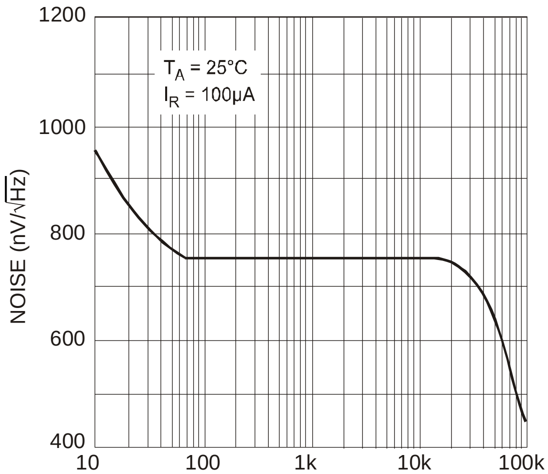
Typical Characteristics – LM4040Q Noise Characteristics



Noise Voltage vs. Frequency
LM4040-25Q

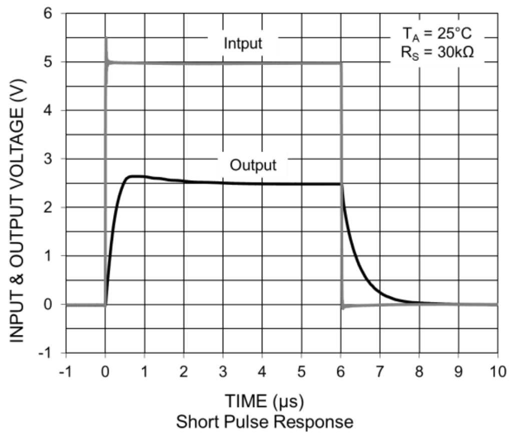


Noise Voltage vs. Frequency
LM4040-30Q

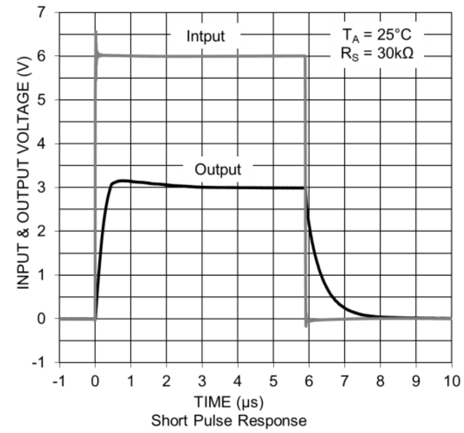


Noise Voltage vs. Frequency
LM4040-50Q

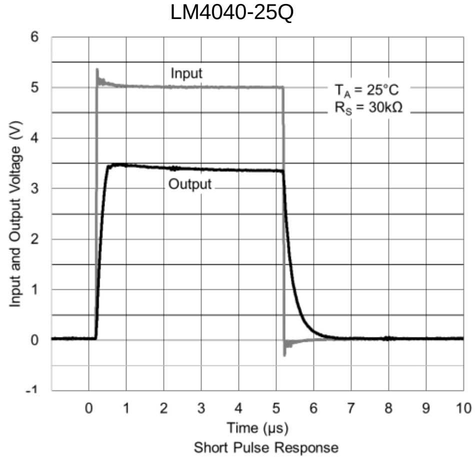
Start Up Characteristics – LM4040Q Short Pulse



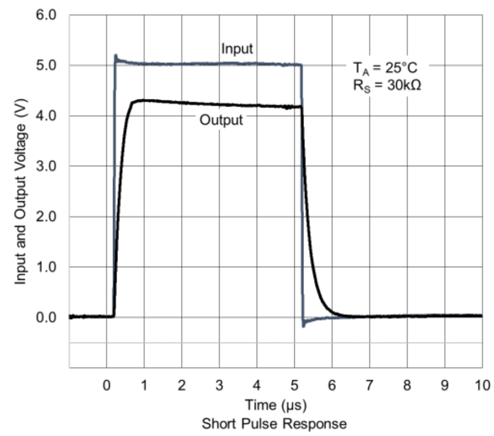
LM4040-25Q



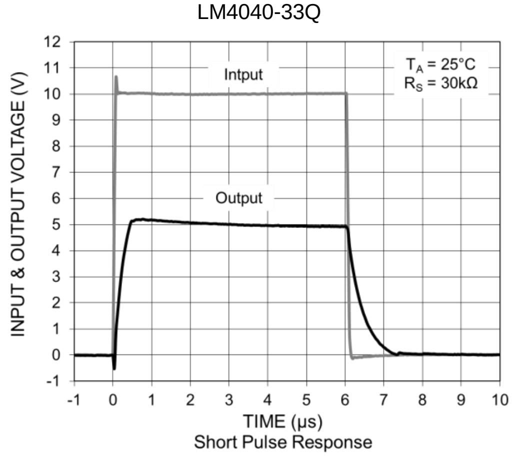
LM4040-30Q



LM4040-33Q

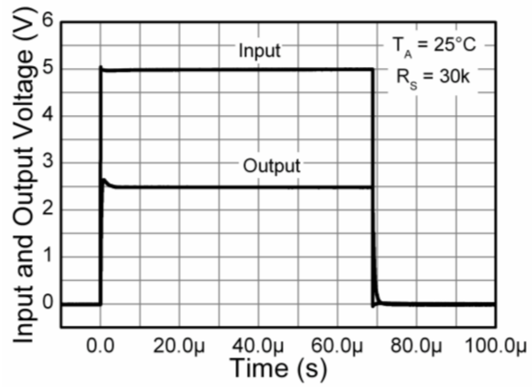


LM4040-41Q



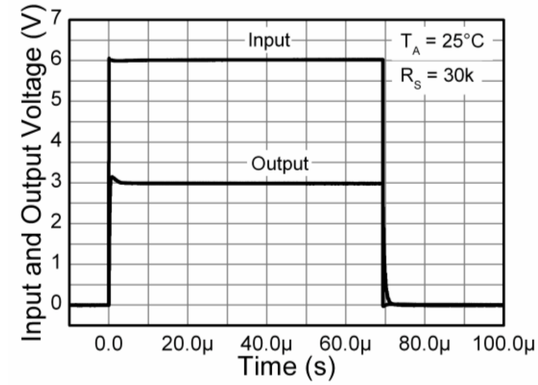
LM4040-50Q

Start Up Characteristics – LM4040Q Long Pulse



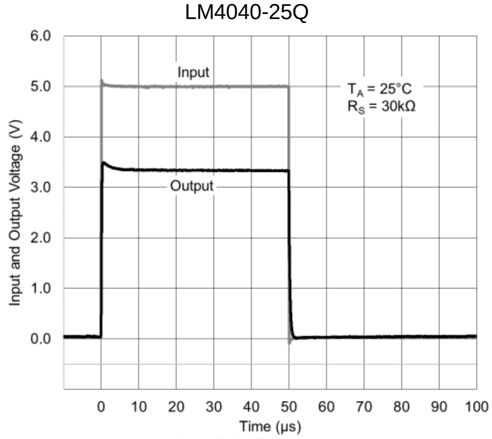
Long Pulse Response

LM4040-25Q



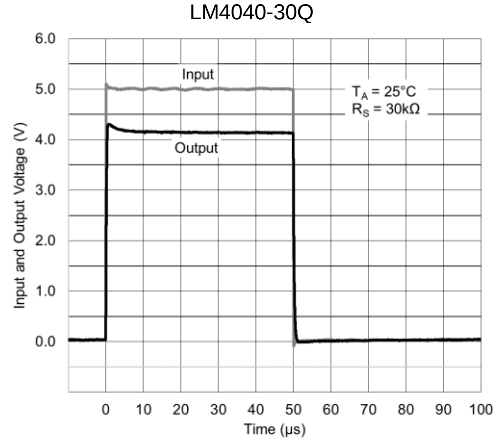
Long Pulse Response

LM4040-30Q



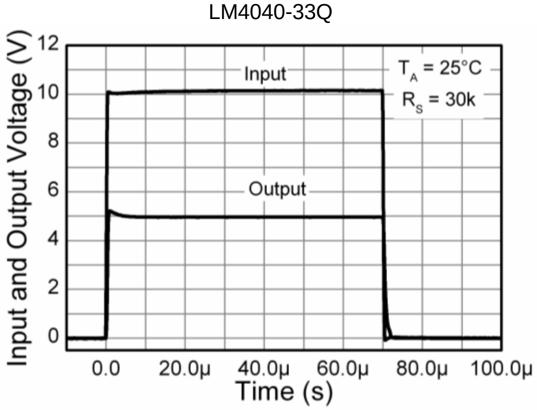
Long Pulse Response

LM4040-33Q



Long Pulse Response

LM4040-41Q



Long Pulse Response

LM4040-50Q

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 LM4040Q.

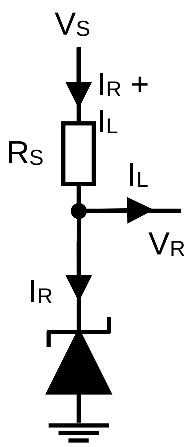


Figure 1

R_S determines the current that flows through the load (I_L) and the LM4040Q (I_R). Because load current and supply voltage can vary, R_S should be small enough to supply at least the minimum acceptable I_R to the LM4040Q 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 the current flowing through the LM4040Q is less than 15mA.

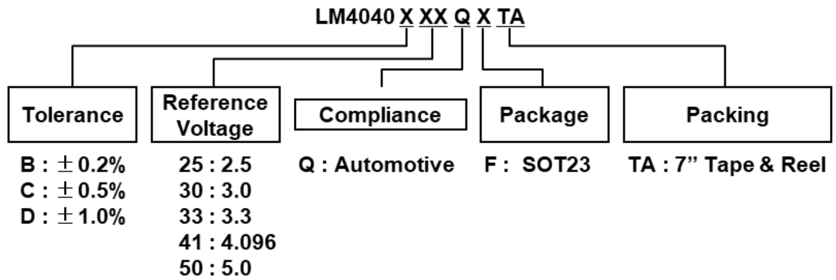
R_S is determined by the supply voltage, (V_S), the load and operating current, (I_L and I_R), and the LM4040Q's reverse breakdown voltage, V_R.

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

Printed Circuit Board Layout Considerations

LM4040Q devices 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 SOT23 package must be left floating or connected to pin 2.

Ordering Information

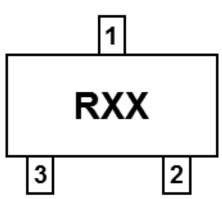


Order Code	25°C Tol	Voltage (V)	Package (Note 5)	Package Code	Identification Code	Packing: 7” Tape and Reel (Note 7)			Compliance (Note 6)
						Quantity	Tape Width	Part Number Suffix	
LM4040B25QFTA	0.2%	2.5	SOT23	F	R2B	3000	8mm	TA	Automotive
LM4040B30QFTA		3.0	SOT23	F	R3B	3000	8mm	TA	Automotive
LM4040B33QFTA		3.3	SOT23	F	3B3Q	3000	8mm	TA	Automotive
LM4040B41QFTA		4.096	SOT23	F	4B1Q	3000	8mm	TA	Automotive
LM4040B50QFTA		5.0	SOT23	F	R5B	3000	8mm	TA	Automotive
LM4040C25QFTA	0.5%	2.5	SOT23	F	R2C	3000	8mm	TA	Automotive
LM4040C30QFTA		3.0	SOT23	F	R3C	3000	8mm	TA	Automotive
LM4040C33QFTA		3.3	SOT23	F	3C3Q	3000	8mm	TA	Automotive
LM4040C41QFTA		4.096	SOT23	F	4C1Q	3000	8mm	TA	Automotive
LM4040C50QFTA		5.0	SOT23	F	R5C	3000	8mm	TA	Automotive
LM4040D25QFTA	1%	2.5	SOT23	F	R2D	3000	8mm	TA	Automotive
LM4040D30QFTA		3.0	SOT23	F	R3D	3000	8mm	TA	Automotive
LM4040D33QFTA		3.3	SOT23	F	3D3Q	3000	8mm	TA	Automotive
LM4040D41QFTA		4.096	SOT23	F	4D1Q	3000	8mm	TA	Automotive
LM4040D50QFTA		5.0	SOT23	F	R5D	3000	8mm	TA	Automotive

Notes: 5. Pad layout as shown in Diodes Incorporated’s package outline PDFs, which can be found on our website at http://www.diodes.com/package-outlines.html.
6. LM4040Q is classified as “Automotive Compliant” and supports PPAP documentation. See LM4040 datasheet for commercial qualified versions.
7. See https://www.diodes.com/assets/Packaging-Support-Docs/ap02007.pdf for tape and reel information.

Marking Information

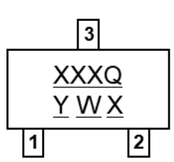
LM4040-25Q, LM4040-30Q, LM4040-50Q



RXX : Identification Code

LM4040-33Q, LM4040-41Q

(Top View)

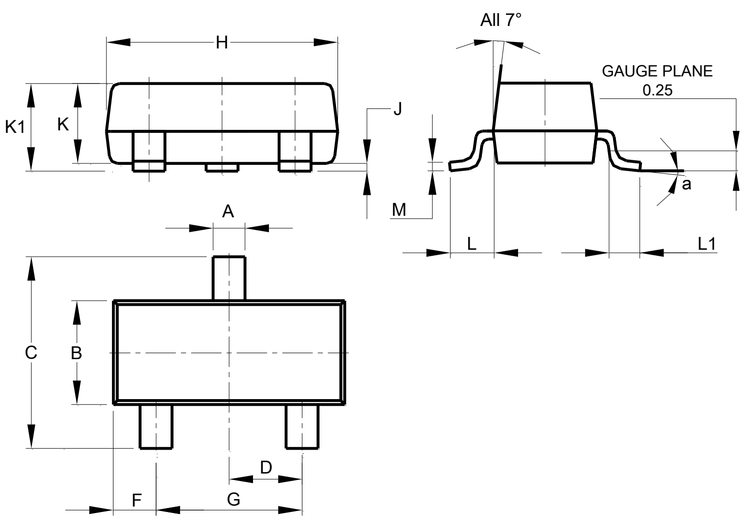


XXXQ : Identification code
Y : Year : 0~9
W : Week: A~Z : 1~26 week;
a~z : 27~52 week; z represents 52 and 53 week
X : Internal code

Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

SOT23

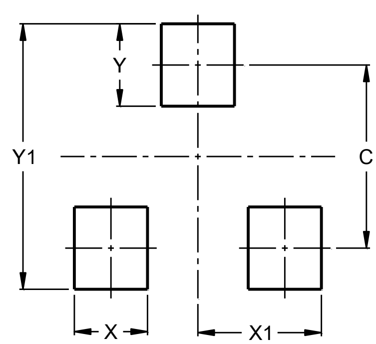


SOT23			
Dim	**Min**	**Max**	**Typ**
A	0.37	0.51	0.40
B	1.20	1.40	1.30
C	2.30	2.50	2.40
D	0.89	1.03	0.915
F	0.45	0.60	0.535
G	1.78	2.05	1.83
H	2.80	3.00	2.90
J	0.013	0.10	0.05
K	0.890	1.00	0.975
K1	0.903	1.10	1.025
L	0.45	0.61	0.55
L1	0.25	0.55	0.40
M	0.085	0.150	0.110
a	0°	8°	--
All Dimensions in mm			

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

SOT23



Dimensions	Value (in mm)
C	2.0
X	0.8
X1	1.35
Y	0.9
Y1	2.9

Note: The suggested land pattern dimensions have been provided for reference only, as actual pad layouts may vary depending on application. These dimensions may be modified based on user equipment capability or fabrication criteria. A more robust pattern may be desired for wave soldering and is calculated by adding 0.2 mm to the 'Z' dimension. For further information, please reference document IPC-7351A, Naming Convention for Standard SMT Land Patterns, and for International grid details, please see document IEC, Publication 97.

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