

Description

The LM4040 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 packages which are 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 so maintaining excellent stability.

This device offers a pin for pin compatible alternative to the LM4040 voltage reference.

Features

- Small Package: SOT23
 - SC70-5 Variants Are End of Life (EOL)
- No Output Capacitor Required
- Output Voltage Tolerance
 - LM4040B ±0.2% at +25°C
 - LM4040C ±0.5% at +25°C
 - LM4040D ±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 Small Package SOT23
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **An Automotive-Compliant Part is Available Under Separate Datasheet ([LM4040Q](#))**

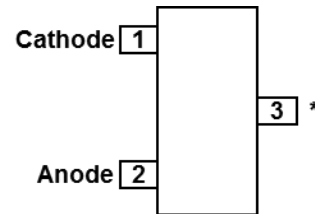
Applications

- Battery Powered Equipment
- Precision Power Supplies
- Portable Instrumentation
- Portable Communications Devices
- Notebook and Palmtop Computers
- 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.

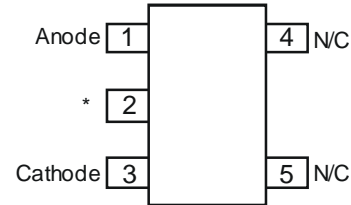
Pin Assignments

(Top View)



* Pin 3 must be left floating or connected to pin 2
SOT23

(Top View)



* Pin 2 must be left floating or connected to pin 1.
** SC70-5 variants are End of Life (EOL).
SC70-5**

Absolute Maximum Ratings (Voltages to Anode 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 |

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.)

Unless otherwise stated voltages specified are relative to the Anode pin.

Package Thermal Data

| Package | θ_{JA} | P_{DIS} $T_A = +25^\circ\text{C}, T_J = +125^\circ\text{C}$ |
|---------|---------------|--|
| SOT23 | 380°C/W | 330mW |

Recommended Operating Conditions

| Parameter | Min | Max | Unit |
|-------------------------------------|------|------|------|
| Reverse Current | 0.06 | 15 | mA |
| Operating Ambient Temperature Range | -40 | +125 | °C |

Electrical Characteristics (Test conditions: $T_A = +25^\circ\text{C}$, unless otherwise specified.)

LM4040-2.5

| Symbol | Parameter | Conditions | | Typ | LM4040 B Limits | LM4040 C Limits | LM4040 D Limits | Unit |
|-------------------------|---|--|---------------|------|--------------------|--------------------|--------------------|-------------------|
| | | — | T_A | | | | | |
| V_{REF} | Reverse Breakdown Voltage | $I_R = 100\mu\text{A}$ | +25°C | 2.5 | — | — | — | V |
| | Reverse Breakdown Voltage Tolerance | $I_R = 100\mu\text{A}$ | +25°C | — | ±5 | ±12 | ±25 | mV |
| | | | -40 to +85°C | — | ±21 | ±29 | ±49 | |
| 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 | $I_R = 10\text{mA}$ | -40 to +125°C | ±20 | — | — | — | ppm/°C |
| | | $I_R = 1\text{mA}$ | | ±15 | ±100 | ±100 | ±150 | |
| | | $I_R = 100\mu\text{A}$ | | ±15 | — | — | — | |
| $\Delta V_R/\Delta I_R$ | Reverse Breakdown Change with Current | $I_{RMIN} \leq I_R \leq 1\text{mA}$ | +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 | |
| | | $1\text{mA} \leq I_R \leq 15\text{mA}$ | +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 | $I_R = 1\text{mA}, f = 120\text{Hz}$ $I_{AC} = 0.1I_R$ | | 0.3 | 0.8 | 0.9 | 1.1 | Ω |
| e_n | Noise Voltage | $I_R = 100\mu\text{A}$ $10\text{Hz} < f < 10\text{kHz}$ | | 35 | — | — | — | µV _{RMS} |
| V_R | Long Term Stability (Non Cumulative) | $t = 1000\text{Hrs}, I_R = 100\mu\text{A}$ | | 120 | — | — | — | ppm |
| V_{HYST} | Thermal Hysteresis | $\Delta T = -40^\circ\text{C to } +125^\circ\text{C}$ | | 0.08 | — | — | — | % |

Electrical Characteristics (Cont.) (Test conditions: $T_A = +25^\circ\text{C}$, unless otherwise specified.)

LM4040-3.0

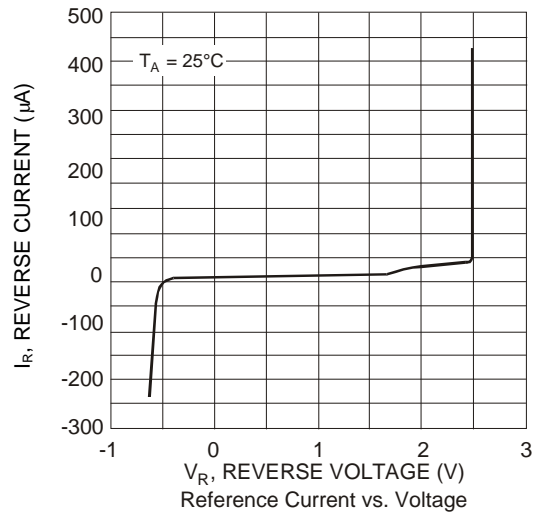
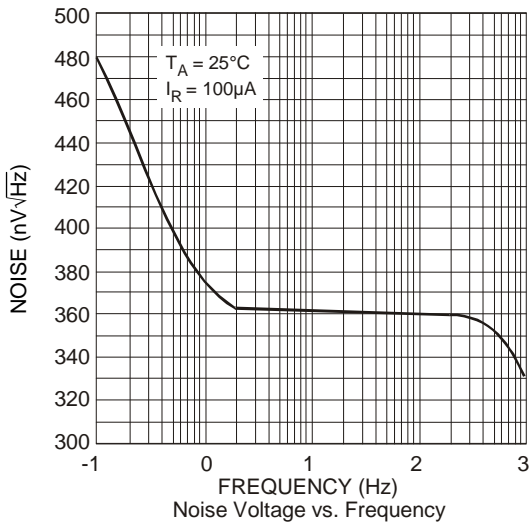
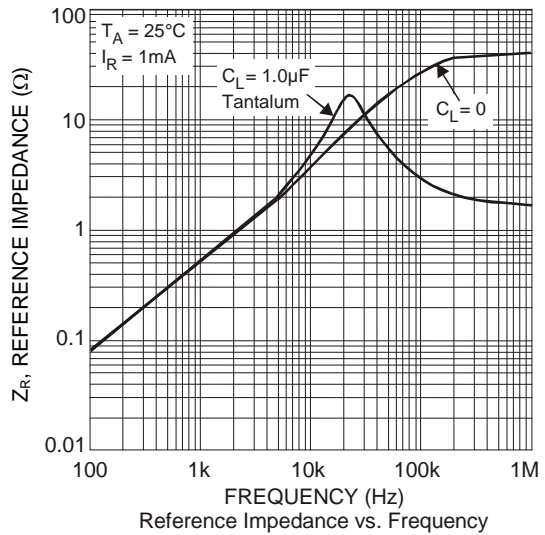
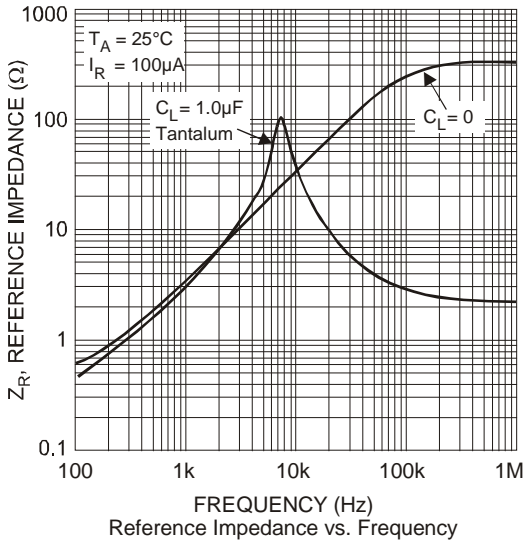
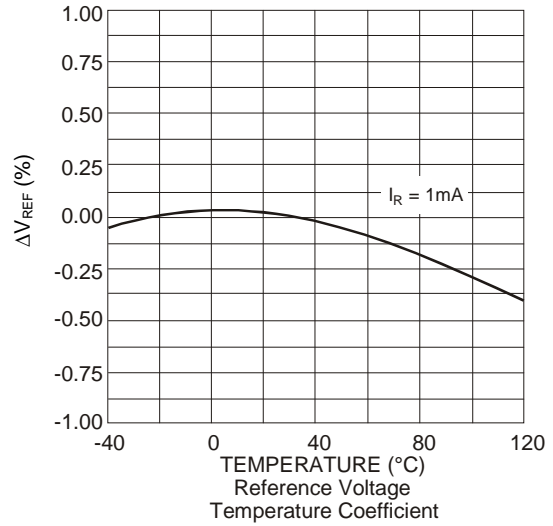
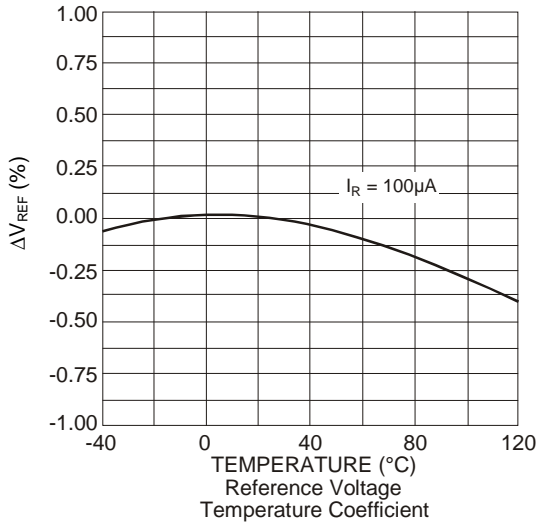
| Symbol | Parameter | Conditions | | Typ | LM4040 B Limits | LM4040 C Limits | LM4040 D Limits | Unit |
|-------------------------|---|---|--|----------|----------------------------|----------------------------------|----------------------------------|-----------------------|
| | | — | T_A | | | | | |
| V_{REF} | Reverse Breakdown Voltage | $I_R = 100\mu\text{A}$ | $+25^\circ\text{C}$ | 3.0 | — | — | — | V |
| | Reverse Breakdown Voltage Tolerance | $I_R = 100\mu\text{A}$ | $+25^\circ\text{C}$ -40 to $+85^\circ\text{C}$ -40 to $+125^\circ\text{C}$ | — | ± 6 ± 26 TBD | ± 15 ± 34 ± 45 | ± 30 ± 59 ± 75 | mV |
| I_{RMIN} | Minimum Operating Current | — | $+25^\circ\text{C}$ | 47 | 62 | 62 | 67 | μA |
| | | | -40 to $+85^\circ\text{C}$ | — | 67 | 67 | 72 | |
| | | | -40 to $+125^\circ\text{C}$ | — | 70 | 70 | 75 | |
| $\Delta V_R/\Delta T$ | Average Reverse Breakdown Voltage Temperature Coefficient | $I_R = 10\text{mA}$ $I_R = 1\text{mA}$ $I_R = 100\mu\text{A}$ | -40 to $+125^\circ\text{C}$ | ± 20 | — | — | — | ppm/ $^\circ\text{C}$ |
| | | | | ± 15 | ± 100 | ± 100 | ± 150 | |
| | | | | ± 15 | — | — | — | |
| $\Delta V_R/\Delta I_R$ | Reverse Breakdown Change with Current | $I_{RMIN} \leq I_R \leq 1\text{mA}$ | $+25^\circ\text{C}$ | 0.4 | 0.8 | 0.8 | 1.0 | mV |
| | | | -40 to $+85^\circ\text{C}$ | — | 1.1 | 1.1 | 1.3 | |
| | | | -40 to $+125^\circ\text{C}$ | — | 1.1 | 1.1 | 1.3 | |
| | | $1\text{mA} \leq I_R \leq 15\text{mA}$ | $+25^\circ\text{C}$ | 2.7 | 6.0 | 6.0 | 8.0 | |
| | | | -40 to $+85^\circ\text{C}$ | — | 9.0 | 9.0 | 11.0 | |
| | | | -40 to $+125^\circ\text{C}$ | — | 9.0 | 9.0 | 11.0 | |
| Z_R | Dynamic Output Impedance | $I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1I_R$ | | 0.4 | 0.9 | 0.9 | 1.2 | Ω |
| e_n | Noise Voltage | $I_R = 100\mu\text{A}$ $10\text{Hz} < f < 10\text{kHz}$ | | 35 | — | — | — | μV_{RMS} |
| V_R | Long Term Stability (Non Cumulative) | $t = 1000\text{Hrs}$, $I_R = 100\mu\text{A}$ | | 120 | — | — | — | ppm |
| V_{HYST} | Thermal Hysteresis | $\Delta T = -40^\circ\text{C}$ to $+125^\circ\text{C}$ | | 0.08 | — | — | — | % |

Electrical Characteristics (Cont.) (Test conditions: $T_A = +25^\circ\text{C}$, unless otherwise specified.)

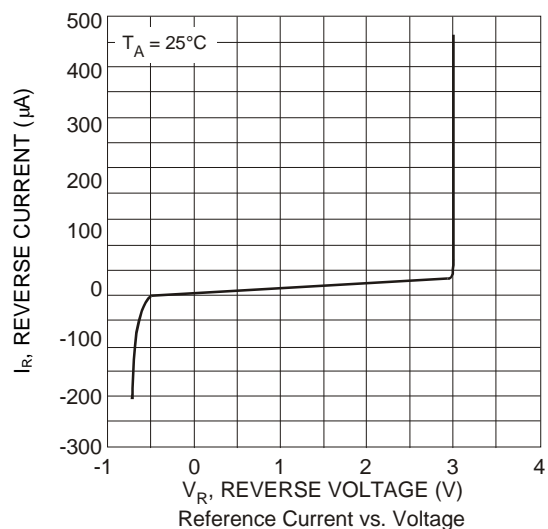
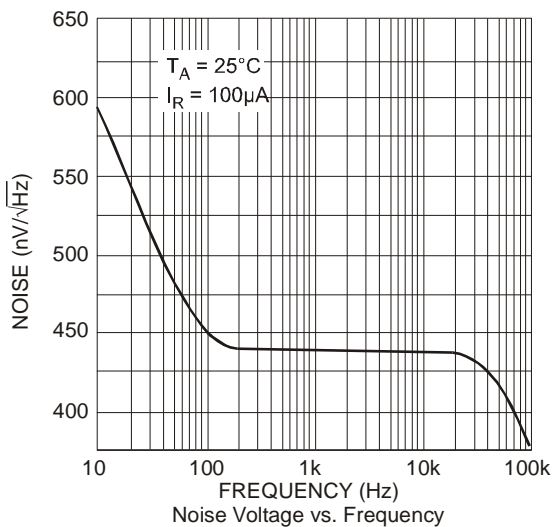
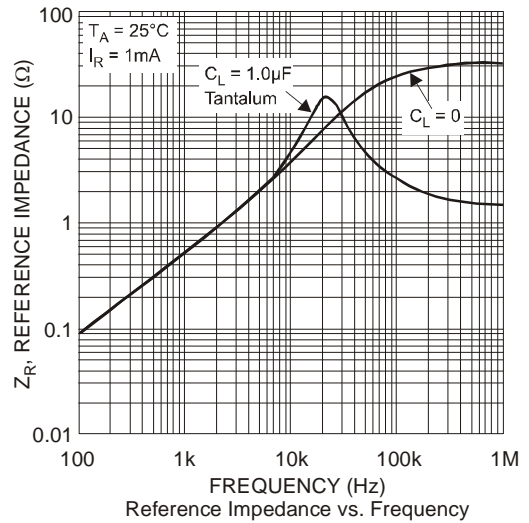
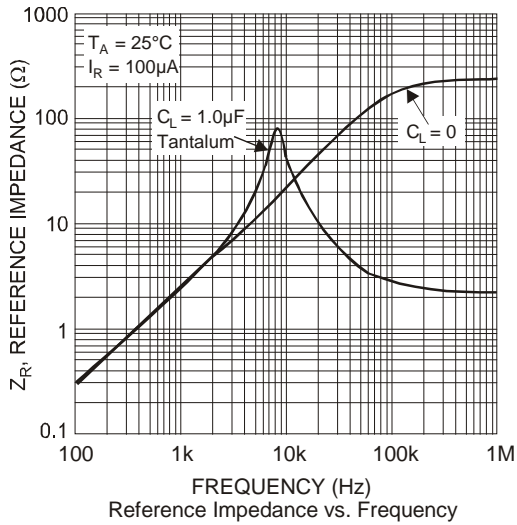
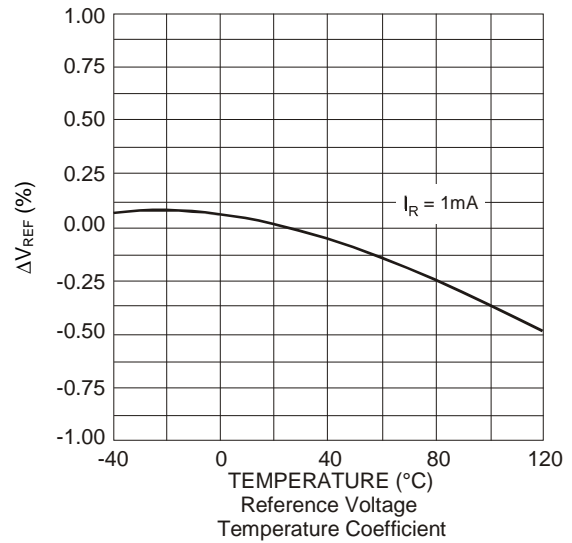
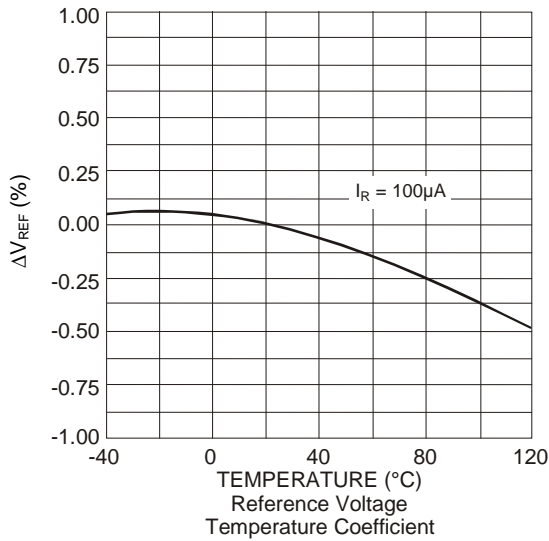
LM4040-5.0

| Symbol | Parameter | Conditions | | Typ | LM4040 B Limits | LM4040 C Limits | LM4040 D Limits | Units |
|-------------------------|---|---|--|----------|----------------------------------|----------------------------------|-----------------------------------|-----------------------|
| | | — | T_A | | | | | |
| V_{REF} | Reverse Breakdown Voltage | $I_R = 100\mu\text{A}$ | $+25^\circ\text{C}$ | 5.0 | — | — | — | V |
| | Reverse Breakdown Voltage Tolerance | $I_R = 100\mu\text{A}$ | $+25^\circ\text{C}$ -40 to $+85^\circ\text{C}$ -40 to $+125^\circ\text{C}$ | — | ± 10 ± 43 ± 60 | ± 25 ± 58 ± 75 | ± 50 ± 99 ± 125 | mV |
| I_{RMIN} | Minimum Operating Current | — | $+25^\circ\text{C}$ | 54 | 74 | 74 | 79 | μA |
| | | | -40 to $+85^\circ\text{C}$ | — | 80 | 80 | 85 | |
| | | | -40 to $+125^\circ\text{C}$ | — | 83 | 83 | 88 | |
| $\Delta V_R/\Delta T$ | Average Reverse Breakdown Voltage Temperature Coefficient | $I_R = 10\text{mA}$ $I_R = 1\text{mA}$ $I_R = 100\mu\text{A}$ | -40 to $+125^\circ\text{C}$ | ± 30 | — | — | — | ppm/ $^\circ\text{C}$ |
| | | | | ± 20 | ± 100 | ± 100 | ± 150 | |
| | | | | ± 20 | — | — | — | |
| $\Delta V_R/\Delta I_R$ | Reverse Breakdown Change with Current | $I_{RMIN} \leq I_R \leq 1\text{mA}$ | $+25^\circ\text{C}$ | 0.5 | 1.0 | 1.0 | 1.3 | mV |
| | | | -40 to $+85^\circ\text{C}$ | — | 1.4 | 1.4 | 1.8 | |
| | | | -40 to $+125^\circ\text{C}$ | — | 1.4 | 1.4 | 1.8 | |
| | | $1\text{mA} \leq I_R \leq 15\text{mA}$ | $+25^\circ\text{C}$ | 3.5 | 8.0 | 8.0 | 10.0 | |
| | | | -40 to $+85^\circ\text{C}$ | — | 12.0 | 12.0 | 15.0 | |
| | | | -40 to $+125^\circ\text{C}$ | — | 12.0 | 12.0 | 15.0 | |
| Z_R | Dynamic Output Impedance | $I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1I_R$ | | 0.5 | 1.1 | 1.1 | 1.5 | Ω |
| e_n | Noise Voltage | $I_R = 100\mu\text{A}$ $10\text{Hz} < f < 10\text{kHz}$ | | 80 | — | — | — | μV_{RMS} |
| V_R | Long Term Stability (Non Cumulative) | $t = 1000\text{Hrs}$, $I_R = 100\mu\text{A}$ | | 120 | — | — | — | ppm |
| V_{HYST} | Thermal Hysteresis | $\Delta T = -40^\circ\text{C}$ to $+125^\circ\text{C}$ | | 0.08 | — | — | — | % |

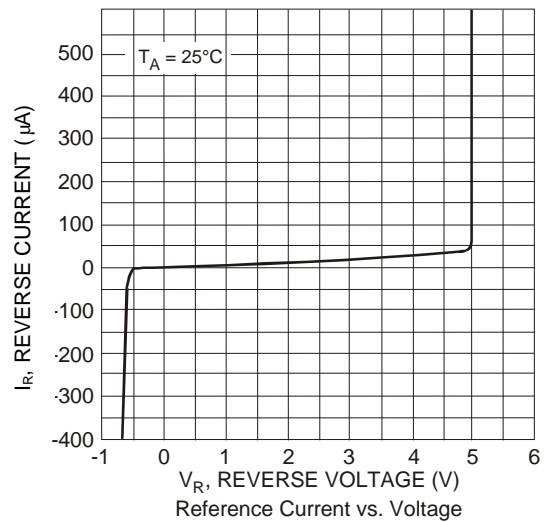
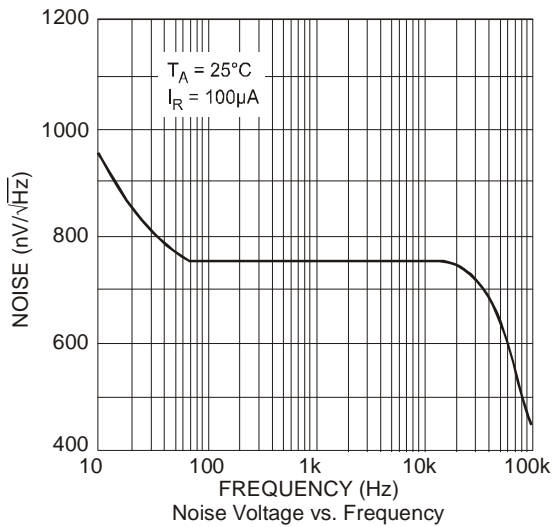
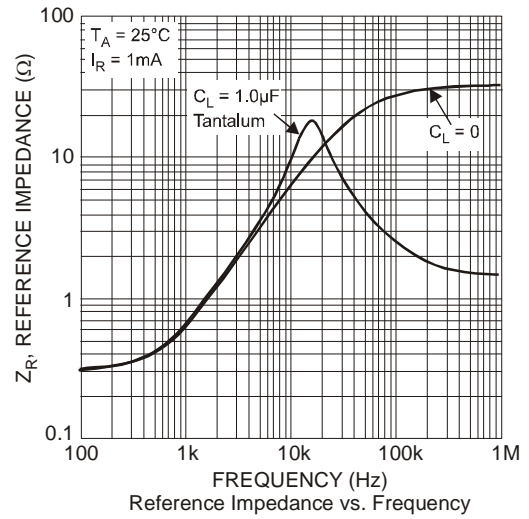
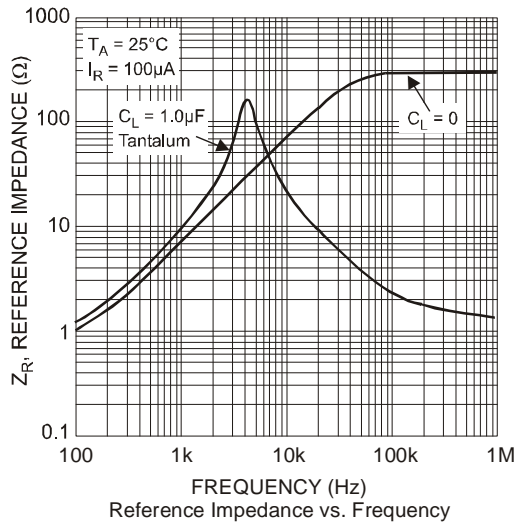
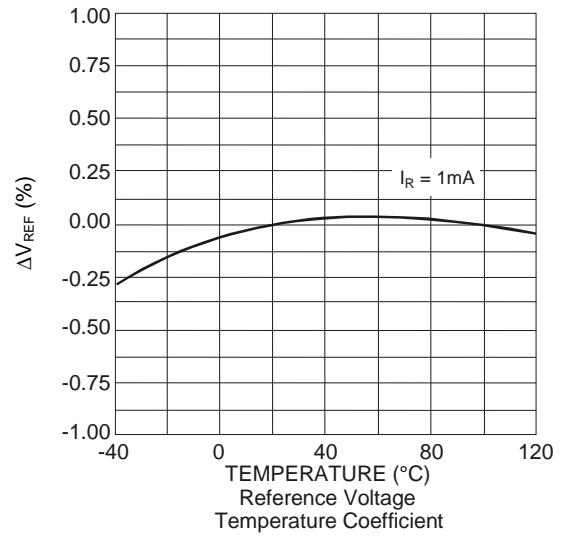
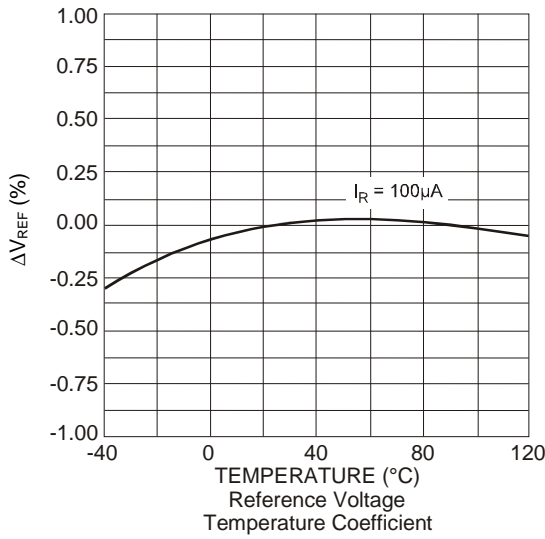
Typical Characteristics LM4040-2.5



Typical Characteristics LM4040-3.0

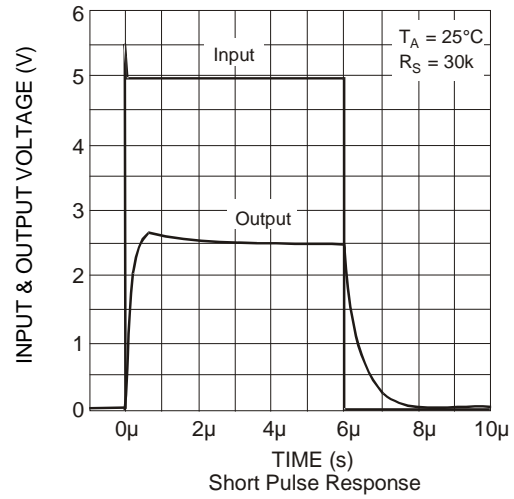
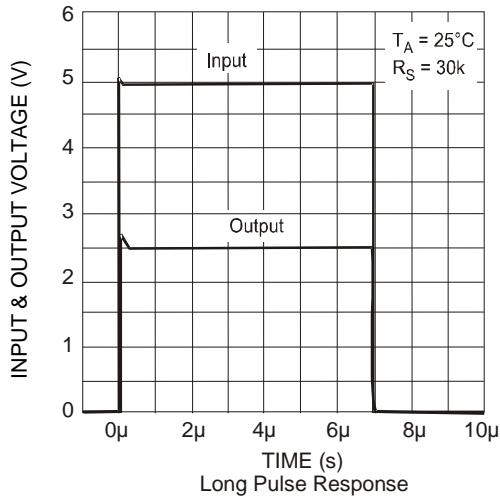


Typical Characteristics LM4040-5.0

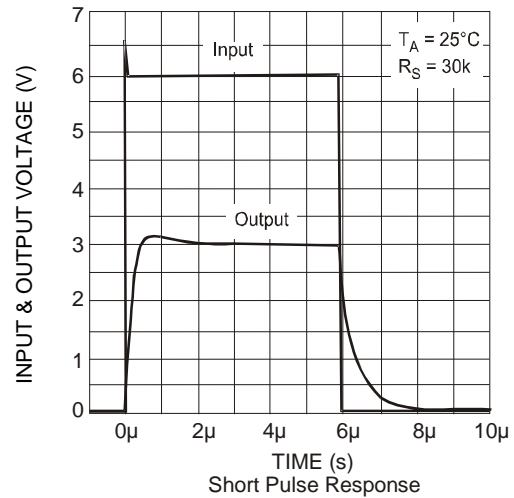
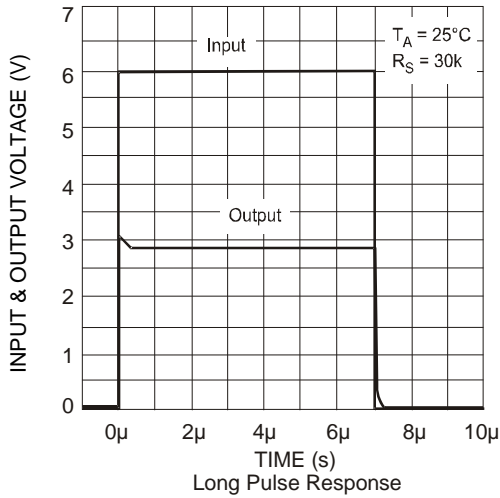


Start Up Characteristics LM4040-2.5, 3.0 and 5.0

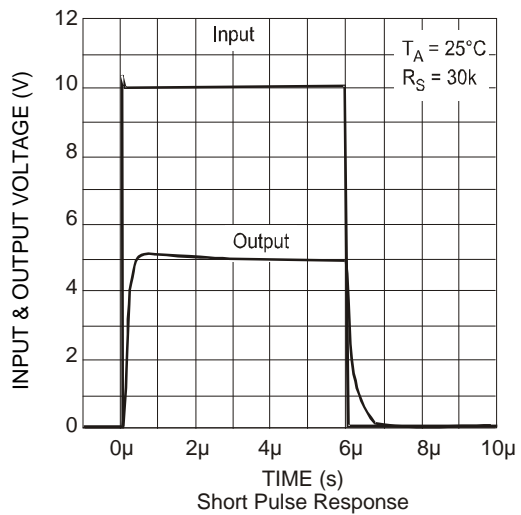
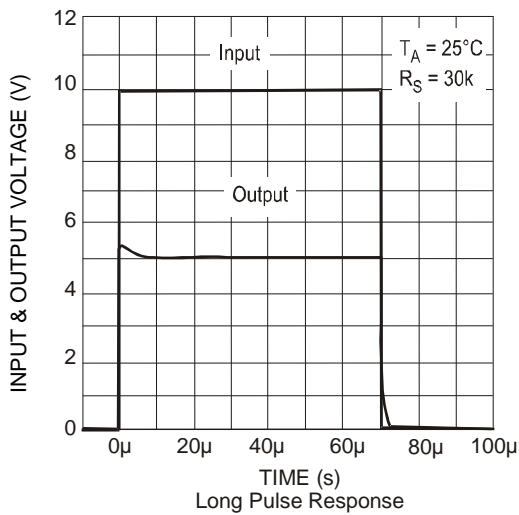
LM4040-2.5



LM4040-3.0

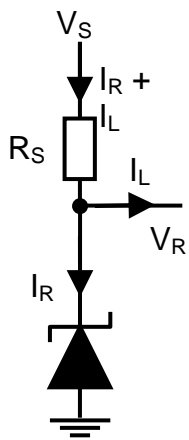


LM4040-5.0



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 15mA.

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 .

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

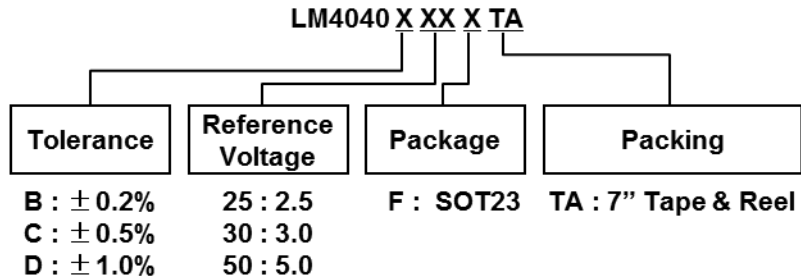
Figure 1

Printed Circuit Board Layout Considerations

LM4040s 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.

LM4040s in the SC70-5 (Note 4) package have the die attached to pin 2, which results in an electrical contact between pin 2 and pin 1. Therefore, pin 2 must be left floating or connected to pin 1.

Note: 4. SC70-5 variants are End of Life (EOL).

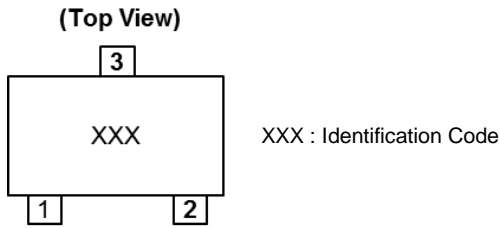
Ordering Information


| +25°C Tol | Voltage (V) | Part Number | Status (Note 4) | Package (Note 5) | Identification Code | Reel Size | Tape Width | Quantity per Reel |
|-----------|-------------|---------------|-----------------|------------------|---------------------|-----------|------------|-------------------|
| 0.2% | 2.5 | LM4040B25FTA | Full Production | SOT23 | R2B | 7", 180mm | 8mm | 3000 |
| | | LM4040B25H5TA | End of Life | SC70-5 | R2B | 7", 180mm | 8mm | 3000 |
| | 3.0 | LM4040B30FTA | Full Production | SOT23 | R3B | 7", 180mm | 8mm | 3000 |
| | | LM4040B30H5TA | End of Life | SC70-5 | R3B | 7", 180mm | 8mm | 3000 |
| | 5.0 | LM4040B50FTA | Full Production | SOT23 | R5B | 7", 180mm | 8mm | 3000 |
| | | LM4040B50H5TA | End of Life | SC70-5 | R5B | 7", 180mm | 8mm | 3000 |
| 0.5% | 2.5 | LM4040C25FTA | Full Production | SOT23 | R2C | 7", 180mm | 8mm | 3000 |
| | | LM4040C25H5TA | End of Life | SC70-5 | R2C | 7", 180mm | 8mm | 3000 |
| | 3.0 | LM4040C30FTA | Full Production | SOT23 | R3C | 7", 180mm | 8mm | 3000 |
| | | LM4040C30H5TA | End of Life | SC70-5 | R3C | 7", 180mm | 8mm | 3000 |
| | 5.0 | LM4040C50FTA | Full Production | SOT23 | R5C | 7", 180mm | 8mm | 3000 |
| | | LM4040C50H5TA | End of Life | SC70-5 | R5C | 7", 180mm | 8mm | 3000 |
| 1% | 2.5 | LM4040D25FTA | Full Production | SOT23 | R2D | 7", 180mm | 8mm | 3000 |
| | | LM4040D25H5TA | End of Life | SC70-5 | R2D | 7", 180mm | 8mm | 3000 |
| | 3.0 | LM4040D30FTA | Full Production | SOT23 | R3D | 7", 180mm | 8mm | 3000 |
| | | LM4040D30H5TA | End of Life | SC70-5 | R3D | 7", 180mm | 8mm | 3000 |
| | 5.0 | LM4040D50FTA | Full Production | SOT23 | R5D | 7", 180mm | 8mm | 3000 |
| | | LM4040D50H5TA | End of Life | SC70-5 | R5D | 7", 180mm | 8mm | 3000 |

Notes: 4. SC70-5 variants are End of Life.
 5. Package dimensions and pad layout can be found on our website at <http://www.diodes.com/package-outlines.html>.

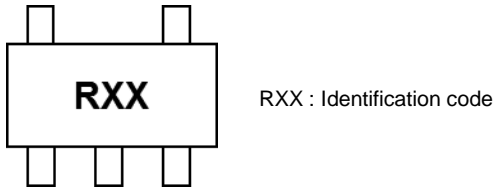
Marking Information

(1) SOT23



| Part Number | Identification Code |
|--------------|---------------------|
| LM4040B25FTA | R2B |
| LM4040B30FTA | R3B |
| LM4040B50FTA | R5B |
| LM4040C25FTA | R2C |
| LM4040C30FTA | R3C |
| LM4040C50FTA | R5C |
| LM4040D25FTA | R2D |
| LM4040D30FTA | R3D |
| LM4040D50FTA | R5D |

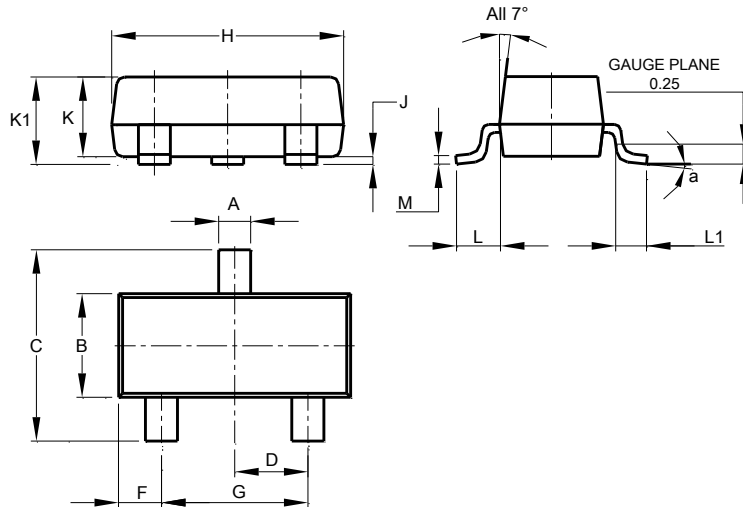
(2) SC70-5 (Note 4)



Package Outline Dimensions

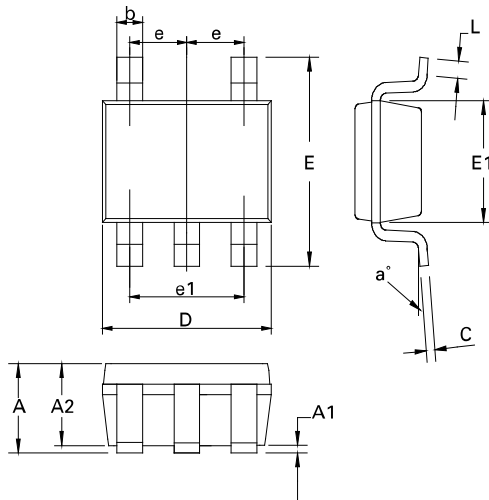
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

(1) Package Type: 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 | | | |

(2) SC70-5 (Note 4)

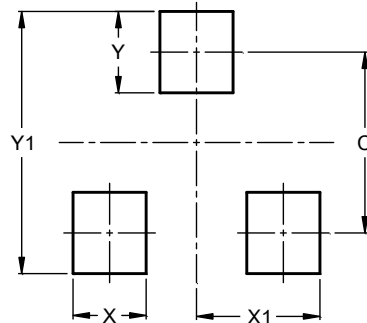


| Dim. | Min. | Max. | Typ. |
|------|----------|------|------|
| A | 1.1 | 0.8 | - |
| A1 | 0.1 | - | - |
| A2 | 1 | 0.8 | - |
| b | 0.3 | 0.15 | - |
| C | 0.25 | 0.08 | - |
| D | 2.00 BSC | | |
| E | 2.10 BSC | | |
| E1 | 1.25 BSC | | |
| e | 0.65 BSC | | |
| e1 | 1.30 BSC | | |
| L | 0.46 | 0.26 | - |
| a° | 0 | 8 | - |

Suggested Pad Layout

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

(1) Package Type: SOT23



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

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