**Features**

- Small SOT-23 Package
- No Output Capacitor Required
- Tolerates Capacitive Loads
- Fixed Reverse-Breakdown Voltages of 1.225V, 2.500V, 4.096V, and 5.000V
- Adjustable Reverse-Breakdown Version

**Applications**

- Battery-Powered Equipment
- Data Acquisition Systems
- Instrumentation
- Process Control
- Energy Management
- Product Testing
- Automotive Electronics
- Precision Audio Components

**General Description**

Ideal for space critical applications, the LM4040 and LM4041 precision voltage references are available in the subminiature SOT-23 surface-mount package.

The LM4040 is available in fixed reverse-breakdown voltages of 2.500V, 4.096V, and 5.000V. The LM4041 is available with a fixed 1.225V or an adjustable reverse-breakdown voltage.

The minimum operating current ranges from 60 μA for the LM4041-1.2 to 74 μA for the LM4040-5.0. LM4040 versions have a maximum operating current of 15 mA. LM4041 versions have a maximum operating current of 12 mA.

The LM4040 and LM4041 have bandgap reference temperature drift curvature correction and low dynamic impedance, ensuring stable reverse-breakdown voltage accuracy over a wide range of operating temperatures and currents.

**Package Types**

<table>
<thead>
<tr>
<th>LM4040/LM4041 (Fixed Version)</th>
<th>LM4041 (Adjustable Version)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Pin SOT-23</td>
<td>3-Pin SOT-23</td>
</tr>
<tr>
<td>NC</td>
<td>FB</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>FB</td>
</tr>
</tbody>
</table>

Precision Micropower Shunt Voltage Reference
Typical Application Diagrams

LM4040/LM4041 Fixed Shunt Regulator Application

LM4041 Adjustable Shunt Regulator Application

Functional Block Diagrams

LM4040/LM4041 Fixed

LM4041 Adjustable
1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †
Reverse Current ...................................................................................................................................................... 20 mA
Forward Current ................................................................................................................................................... 10 mA
Maximum Output Voltage (LM4041-ADJ) ................................................................................................................... 15V
Power Dissipation (TA = +25°C; Note 1) .............................................................................................................. 306 mW
ESD Susceptibility (HBM; Note 2) .............................................................................................................................. 2 kV
ESD Susceptibility (MM; Note 2) .............................................................................................................................. 200V

Operating Ratings ‡
Reverse Current (LM4040-2.5) .................................................................................................................................. 60 µA to 15 mA
Reverse Current (LM4040-4.1) .................................................................................................................................. 68 µA to 15 mA
Reverse Current (LM4040-5.0) .................................................................................................................................. 74 µA to 15 mA
Reverse Current (LM4041-1.2) .................................................................................................................................. 60 µA to 12 mA
Reverse Current (LM4041-ADJ) ............................................................................................................................... 60 µA to 12 mA
Output Voltage Range (LM4041-ADJ) ....................................................................................................................... 1.24V to 10V

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ Notice: The device is not guaranteed to function outside its operating ratings.

Note 1: The maximum power dissipation must be derated at elevated temperatures and is dictated by \( P_{D\text{MAX}} = \frac{(T_{J\text{MAX}} - T_A)}{\Theta_{JA}} \) or the number given in the Absolute Maximum Ratings, whichever is lower. For the LM4040 and LM4041, \( T_{J\text{MAX}} = +125°C \) and the typical thermal resistance, when board-mounted, is +326°C/W for the SOT-23 package.

2: Devices are ESD sensitive. Handling precautions are recommended. Human body model, 1.5 kΩ in series with 100 pF. The machine model is a 200 pF capacitor discharged directly into each pin.
### LM4040-2.5 ELECTRICAL CHARACTERISTICS (Note 1)

\( T_A = \) Operating Temperature Range, \( T_A = T_J = -40^\circ C \) to \(+85^\circ C\), unless noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LM4040C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage</td>
<td>( V_R )</td>
<td>—</td>
<td>2.500</td>
<td>—</td>
<td>V</td>
<td>( I_R = 100 \mu A, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Tolerance (Note 2)</td>
<td></td>
<td>—</td>
<td>±12</td>
<td>—</td>
<td>mV</td>
<td>( I_R = 100 \mu A, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>( I_{RMIN} )</td>
<td>—</td>
<td>45</td>
<td>60</td>
<td>( \mu A )</td>
<td>( T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Average Reverse-Breakdown Voltage Temperature</td>
<td>( \Delta V_R/\Delta T )</td>
<td>—</td>
<td>±20</td>
<td>—</td>
<td>ppm/°C</td>
<td>( I_R = 10 \text{ mA}, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td>—</td>
<td>±15</td>
<td>±100</td>
<td></td>
<td>( I_R = 1 \text{ mA} )</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Change with Operating Current Change</td>
<td>( \Delta V_R/\Delta I_R )</td>
<td>—</td>
<td>0.3</td>
<td>0.8</td>
<td>mV</td>
<td>( I_{RMIN} \leq I_R \leq 1 \text{ mA}, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td></td>
<td>—</td>
<td>1.0</td>
<td>—</td>
<td></td>
<td>( I_R = 100 \mu A, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>( Z_R )</td>
<td>—</td>
<td>0.3</td>
<td>0.9</td>
<td>( \Omega )</td>
<td>( I_R = 1 \text{ mA}, f = 120 \text{ Hz}, I_{AC} = 0.1 I_R, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>( e_N )</td>
<td>—</td>
<td>35</td>
<td>—</td>
<td>( \mu V_{RMS} )</td>
<td>( I_R = 100 \mu A, T_A = +25^\circ C ), 10 \text{ Hz} \leq f \leq 10 \text{ kHz}</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>( \Delta V_R )</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>ppm</td>
<td>( t = 1000 \text{ hrs.}, T_A = +25^\circ C \pm 0.1^\circ C, I_R = 100 \mu A )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LM4040D</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage</td>
<td>( V_R )</td>
<td>—</td>
<td>2.500</td>
<td>—</td>
<td>V</td>
<td>( I_R = 100 \mu A, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Tolerance (Note 2)</td>
<td></td>
<td>—</td>
<td>±25</td>
<td>—</td>
<td>mV</td>
<td>( I_R = 100 \mu A, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>( I_{RMIN} )</td>
<td>—</td>
<td>45</td>
<td>65</td>
<td>( \mu A )</td>
<td>( T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Average Reverse-Breakdown Voltage Temperature</td>
<td>( \Delta V_R/\Delta T )</td>
<td>—</td>
<td>±20</td>
<td>—</td>
<td>ppm/°C</td>
<td>( I_R = 10 \text{ mA}, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td>—</td>
<td>±15</td>
<td>±150</td>
<td></td>
<td>( I_R = 1 \text{ mA} )</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td></td>
<td>—</td>
<td>±15</td>
<td>—</td>
<td></td>
<td>( I_R = 100 \mu A, T_A = +25^\circ C )</td>
</tr>
</tbody>
</table>

**Note 1:** Specification for packaged product only.

**Note 2:** The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance \( \pm \left( \frac{\Delta V_R}{\Delta T} \right)(T_A - 25°C) \), \( \Delta V_R/\Delta T \) is the \( V_R \) temperature coefficient, 65°C is the temperature range from -40°C to the reference point of 25°C, and \( V_R \) is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: \( \pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/°C} \times 65°C \)
b. D-grade: \( \pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/°C} \times 65°C \)

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of \( 2.5 \times 1.15\% = 29 \text{ mV} \).
**LM4040/LM4041**

**LM4040-2.5 ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)**

\( T_A = \) Operating Temperature Range, \( T_A = T_J = -40^\circ C \) to \(+85^\circ C\), unless noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse-Breakdown Voltage Change with Operating Current Change</td>
<td>( \Delta V_R/\Delta I_R )</td>
<td>—</td>
<td>0.3</td>
<td>1.0</td>
<td>mV</td>
<td>( I_{RMIN} \leq I_R \leq 1 mA,) ( T_A = +25^\circ C )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>1.2</td>
<td></td>
<td>( I_{RMIN} \leq I_R \leq 1 mA )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>2.5</td>
<td>8.0</td>
<td></td>
<td>( 1 \text{ mA} \leq I_R \leq 15 \text{ mA},) ( T_A = +25^\circ C )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>10.0</td>
<td></td>
<td>( 1 \text{ mA} \leq I_R \leq 15 \text{ mA} )</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>( Z_R )</td>
<td>—</td>
<td>0.3</td>
<td>1.1</td>
<td>( \Omega )</td>
<td>( I_R = 1 \text{ mA}, f = 120 \text{ Hz},) ( I_{AC} = 0.1 I_R, T_A = +25^\circ C )</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>( e_N )</td>
<td>—</td>
<td>35</td>
<td>—</td>
<td>( \mu V_{RMS} )</td>
<td>( I_R = 100 \mu A,) ( 10 \text{ Hz} \leq f \leq 10 \text{ kHz} )</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>( \Delta V_R )</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>ppm</td>
<td>( t = 1000 \text{ hrs.}, T_A = +25^\circ C) ( \pm 0.1^\circ C, I_R = 100 \mu A )</td>
</tr>
</tbody>
</table>

**Note 1:** Specification for packaged product only.

**2:** The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance \( \pm(\Delta V_R/\Delta T)(65^\circ C)(V_R) \). \( \Delta V_R/\Delta T \) is the \( V_R \) temperature coefficient, 65°C is the temperature range from \(-40^\circ C\) to the reference point of 25°C, and \( V_R \) is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

- **a.** C-grade: \( \pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm}/^\circ C \times 65^\circ C \)
- **b.** D-grade: \( \pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm}/^\circ C \times 65^\circ C \)

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of \( \pm 2.5 \times 1.15\% = \pm 29 \text{ mV} \).
# LM4040-4.1 ELECTRICAL CHARACTERISTICS (Note 1)

$T_A$ = Operating Temperature Range, $T_A = T_J = -40^\circ C$ to $+85^\circ C$, unless noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM4040C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage</td>
<td>$V_R$</td>
<td>—</td>
<td>4.096</td>
<td>—</td>
<td>V</td>
<td>$I_R = 100\ \mu A, \ T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Tolerance (Note 2)</td>
<td>$I_{RMIN}$</td>
<td>—</td>
<td>50</td>
<td>68</td>
<td>$\mu A$</td>
<td>$T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>$I_{RMIN}$</td>
<td>—</td>
<td>73</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Average Reverse-Breakdown Voltage Temperature Coefficient</td>
<td>$\Delta V_R/\Delta T$</td>
<td>—</td>
<td>±30</td>
<td>—</td>
<td>ppm/°C</td>
<td>$I_R = 10\ mA, \ T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Change with Operating Current Change</td>
<td>$\Delta V_R/\Delta I_R$</td>
<td>—</td>
<td>0.5</td>
<td>0.9</td>
<td>mV</td>
<td>$I_{RMIN} \leq I_R \leq 1\ mA, \ T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>$Z_R$</td>
<td>—</td>
<td>0.5</td>
<td>1.0</td>
<td>Ω</td>
<td>$I_R = 1\ mA, \ f = 120\ Hz, \ I_{AC} = 0.1\ I_R, \ T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>$e_N$</td>
<td>—</td>
<td>80</td>
<td>—</td>
<td>$\mu V_{RMS}$</td>
<td>$I_R = 100\ \mu A, \ 10\ Hz \leq f \leq 10\ kHz$</td>
</tr>
<tr>
<td>LM4040D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage</td>
<td>$V_R$</td>
<td>—</td>
<td>4.096</td>
<td>—</td>
<td>V</td>
<td>$I_R = 100\ \mu A, \ T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Tolerance (Note 2)</td>
<td>$I_{RMIN}$</td>
<td>—</td>
<td>50</td>
<td>73</td>
<td>$\mu A$</td>
<td>$T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>$I_{RMIN}$</td>
<td>—</td>
<td>78</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Average Reverse-Breakdown Voltage Temperature Coefficient</td>
<td>$\Delta V_R/\Delta T$</td>
<td>—</td>
<td>±30</td>
<td>—</td>
<td>ppm/°C</td>
<td>$I_R = 10\ mA, \ T_A = +25^\circ C$</td>
</tr>
</tbody>
</table>

**Note 1:** Specification for packaged product only.

**Note 2:** The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance $\pm[(\Delta V_R/\Delta T)(65^\circ C)(V_R)]$. $\Delta V_R/\Delta T$ is the $V_R$ temperature coefficient, $65^\circ C$ is the temperature range from $-40^\circ C$ to the reference point of $25^\circ C$, and $V_R$ is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: $\pm1.15\% = \pm0.5\% \pm100\ ppm/^\circ C \times 65^\circ C$
b. D-grade: $\pm1.98\% = \pm1.0\% \pm150\ ppm/^\circ C \times 65^\circ C$

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of $\pm2.5 \times 1.15\% = \pm29\ mV$. 
LM4040/LM4041

**LM4040-4.1 ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)**

$T_A = $ Operating Temperature Range, $T_A = T_J = -40^\circ C$ to $+85^\circ C$, unless noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse-Breakdown Voltage Change with Operating Current Change</td>
<td>$\Delta V_R/\Delta I_R$</td>
<td>—</td>
<td>0.5</td>
<td>1.2</td>
<td>mV</td>
<td>$I_{RMIN} \leq I_R \leq 1 mA$, $T_A = +25^\circ C$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$I_{RMIN} \leq I_R \leq 1 mA$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.0</td>
<td>9.0</td>
<td></td>
<td>$1 mA \leq I_R \leq 15 mA$, $T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>$Z_R$</td>
<td>—</td>
<td>0.5</td>
<td>1.3</td>
<td>$\Omega$</td>
<td>$I_R = 1 mA$, $f = 120 Hz$, $I_{AC} = 0.1 I_R$, $T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>$e_N$</td>
<td>—</td>
<td>80</td>
<td>—</td>
<td>$\mu V_{RMS}$</td>
<td>$I_R = 100 \mu A$, $T_A = +25^\circ C$ $10$ Hz $\leq f \leq 10$ kHz</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>$\Delta V_R$</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>ppm</td>
<td>$t = 1000$ hrs., $T_A = +25^\circ C$ $\pm 0.1^\circ C$, $I_R = 100 \mu A$</td>
</tr>
</tbody>
</table>

**Note 1:** Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance $\pm\left(\Delta V_R/\Delta T\right)\left(65^\circ C\right)/V_R$. $\Delta V_R/\Delta T$ is the $V_R$ temperature coefficient, $65^\circ C$ is the temperature range from $-40^\circ C$ to the reference point of $25^\circ C$, and $V_R$ is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100$ ppm/$^\circ C \times 65^\circ C$

b. D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150$ ppm/$^\circ C \times 65^\circ C$

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of $\pm 2.5 \times 1.15\% = \pm 29$ mV.
**LM4040-5.0 ELECTRICAL CHARACTERISTICS (Note 1)**

*TA = Operating Temperature Range, TA = TJ = –40°C to +85°C, unless noted.*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM4040C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage</td>
<td>$V_R$</td>
<td>—</td>
<td>5.000</td>
<td>—</td>
<td>V</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Tolerance (Note 2)</td>
<td></td>
<td></td>
<td>±25</td>
<td>—</td>
<td>mV</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>$I_{RMIN}$</td>
<td>—</td>
<td>54</td>
<td>74</td>
<td>µA</td>
<td>$T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Average Reverse-Breakdown Voltage Temperature</td>
<td>$\Delta V_R/\Delta T$</td>
<td>—</td>
<td>±30</td>
<td>—</td>
<td>ppm/°C</td>
<td>$I_R = 10 \text{ mA}, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Change with Operating Current Change</td>
<td>$\Delta V_R/\Delta I_R$</td>
<td>—</td>
<td>0.5</td>
<td>1.0</td>
<td>mV</td>
<td>$I_{RMIN} \leq I_R \leq 1 \text{ mA}, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>$Z_R$</td>
<td>—</td>
<td>0.5</td>
<td>1.1</td>
<td>Ω</td>
<td>$I_R = 1 \text{ mA}, f = 120 \text{ Hz}, I_{AC} = 0.1 I_R, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>$e_N$</td>
<td>—</td>
<td>80</td>
<td>—</td>
<td>µV RMS</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ C, 10 \text{ Hz} \leq f \leq 10 \text{ kHz}$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>$\Delta V_R$</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>ppm</td>
<td>$t = 1000 \text{ hrs.}, T_A = +25^\circ C \pm 0.1^\circ C, I_R = 100 \mu A$</td>
</tr>
<tr>
<td>LM4040D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage</td>
<td>$V_R$</td>
<td>—</td>
<td>5.000</td>
<td>—</td>
<td>V</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Tolerance (Note 2)</td>
<td></td>
<td></td>
<td>±50</td>
<td>—</td>
<td>mV</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>$I_{RMIN}$</td>
<td>—</td>
<td>54</td>
<td>79</td>
<td>µA</td>
<td>$T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Average Reverse-Breakdown Voltage Temperature</td>
<td>$\Delta V_R/\Delta T$</td>
<td>—</td>
<td>±30</td>
<td>—</td>
<td>ppm/°C</td>
<td>$I_R = 10 \text{ mA}, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Change with Operating Current Change</td>
<td>$\Delta V_R/\Delta I_R$</td>
<td>—</td>
<td>±20</td>
<td>±150</td>
<td>mV</td>
<td>$I_R = 1 \text{ mA}$</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>$Z_R$</td>
<td>—</td>
<td>0.5</td>
<td>1.1</td>
<td>Ω</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>$e_N$</td>
<td>—</td>
<td>80</td>
<td>—</td>
<td>µV RMS</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>$\Delta V_R$</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>ppm</td>
<td>$t = 1000 \text{ hrs.}, T_A = +25^\circ C \pm 0.1^\circ C, I_R = 100 \mu A$</td>
</tr>
</tbody>
</table>

**Note 1:** Specification for packaged product only.

**Note 2:** The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±($\Delta V_R/\Delta T$)(65°C)(VR). $\Delta V_R/\Delta T$ is the VR temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and VR is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C
b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.
LM4040-5.0 ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

$T_A =$ Operating Temperature Range, $T_A = T_J = -40^\circ C$ to $+85^\circ C$, unless noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse-Breakdown Voltage Change with Operating Current Change</td>
<td>$\Delta V_R/\Delta I_R$</td>
<td>—</td>
<td>0.5</td>
<td>1.3</td>
<td>mV</td>
<td>$I_{RMIN} \leq I_R \leq 1\ mA, T_A = +25^\circ C$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>1.8</td>
<td></td>
<td>$I_{RMIN} \leq I_R \leq 1\ mA$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>3.5</td>
<td>10.0</td>
<td></td>
<td>$1\ mA \leq I_R \leq 15\ mA, T_A = +25^\circ C$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>15.0</td>
<td></td>
<td>$1\ mA \leq I_R \leq 15\ mA$</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>$Z_R$</td>
<td>—</td>
<td>0.5</td>
<td>1.5</td>
<td>$\Omega$</td>
<td>$I_R = 1\ mA, f = 120\ Hz, I_{AC} = 0.1\ I_R, T_A = +25^\circ C$</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>$e_N$</td>
<td>—</td>
<td>80</td>
<td>—</td>
<td>$\mu V_{RMS}$</td>
<td>$I_R = 100\ \mu A, T_A = +25^\circ C, 10\ Hz \leq f \leq 10\ kHz$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>$\Delta V_R$</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>ppm</td>
<td>$t = 1000\ hrs., T_A = +25^\circ C \pm 0.1^\circ C, I_R = 100\ \mu A$</td>
</tr>
</tbody>
</table>

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance $\pm(\Delta V_R/\Delta T)(65^\circ C)/(V_R)$. $\Delta V_R/\Delta T$ is the $V_R$ temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and $V_R$ is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: $\pm1.15\% = \pm0.5\% \times 65^\circ C$ 
b. D-grade: $\pm1.98\% = \pm1.0\% \times 150^\circ C$ 

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of $\pm2.5 \times 1.15\% = \pm29\ mV$. 
### LM4041-1.2 ELECTRICAL CHARACTERISTICS (Note 1)

$T_A = \text{Operating Temperature Range, } T_A = T_J = -40^\circ\text{C to } +85^\circ\text{C, unless noted.}$

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LM4041C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage</td>
<td>$V_R$</td>
<td>---</td>
<td>1.225</td>
<td>---</td>
<td>V</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Tolerance (Note 2)</td>
<td>---</td>
<td>---</td>
<td>±6</td>
<td>---</td>
<td>mV</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>$I_{RMIN}$</td>
<td>---</td>
<td>45</td>
<td>60</td>
<td>µA</td>
<td>$T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Average Reverse-Breakdown Voltage Temperature Coefficient</td>
<td>$\Delta V_R/\Delta T$</td>
<td>---</td>
<td>±20</td>
<td>---</td>
<td>ppm/°C</td>
<td>$I_R = 10 \text{ mA, } T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Change with Operating Current Change</td>
<td>$\Delta V_R/\Delta I_R$</td>
<td>---</td>
<td>0.7</td>
<td>1.5</td>
<td>mV</td>
<td>$I_{RMIN} \leq I_R \leq 1 \text{ mA, } T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>$Z_R$</td>
<td>---</td>
<td>0.5</td>
<td>1.5</td>
<td>Ω</td>
<td>$I_R = 1 \text{ mA, } f = 120 \text{ Hz, } I_{AC} = 0.1 I_R, T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>$e_N$</td>
<td>---</td>
<td>20</td>
<td>---</td>
<td>µV RMS</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ\text{C, 10 Hz} \leq f \leq 10 \text{ kHz}$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>$\Delta V_R$</td>
<td>---</td>
<td>120</td>
<td>---</td>
<td>ppm</td>
<td>$t = 1000 \text{ hrs., } T_A = +25^\circ\text{C} \pm0.1^\circ\text{C, } I_R = 100 \mu A$</td>
</tr>
</tbody>
</table>

| **LM4041D** |
| Reverse-Breakdown Voltage | $V_R$ | --- | 1.225 | --- | V | $I_R = 100 \mu A, T_A = +25^\circ\text{C}$ |
| Reverse-Breakdown Voltage Tolerance (Note 2) | --- | --- | ±12 | --- | mV | $I_R = 100 \mu A, T_A = +25^\circ\text{C}$ |
| Minimum Operating Current | $I_{RMIN}$ | --- | 45 | 65 | µA | $T_A = +25^\circ\text{C}$ |
| Average Reverse-Breakdown Voltage Temperature Coefficient | $\Delta V_R/\Delta T$ | --- | ±20 | --- | ppm/°C | $I_R = 10 \text{ mA, } T_A = +25^\circ\text{C}$ |

**Note 1:** Specification for packaged product only.

**Note 2:** The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance $\pm[(\Delta V_R/\Delta T)(65^\circ\text{C})/(V_R)]$. $\Delta V_R/\Delta T$ is the $V_R$ temperature coefficient, 65°C is the temperature range from $-40^\circ\text{C}$ to the reference point of 25°C, and $V_R$ is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: $\pm1.15\% = \pm0.5\% \pm100 \text{ ppm/°C} \times 65^\circ\text{C}$
b. D-grade: $\pm1.98\% = \pm1.0\% \pm150 \text{ ppm/°C} \times 65^\circ\text{C}$

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of $\pm2.5 \times 1.15\% = \pm29 \text{ mV}$. 
LM4040/LM4041

LM4041-1.2 ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

\(T_A = \) Operating Temperature Range, \(T_A = T_J = -40^\circ C \text{ to } +85^\circ C, \) unless noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse-Breakdown Voltage Change with Operating Current Change</td>
<td>(\Delta V_R/\Delta I_R)</td>
<td>—</td>
<td>0.7</td>
<td>2.0</td>
<td>mV</td>
<td>(I_{RMIN} \leq I_R \leq 1 \text{ mA}, ; T_A = +25^\circ C)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>2.5</td>
<td></td>
<td></td>
<td>(I_{RMIN} \leq I_R \leq 1 \text{ mA})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>2.5</td>
<td>8.0</td>
<td></td>
<td>(1 \text{ mA} \leq I_R \leq 12 \text{ mA}, ; T_A = +25^\circ C)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>10.0</td>
<td></td>
<td>(1 \text{ mA} \leq I_R \leq 12 \text{ mA})</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>(Z_R)</td>
<td>—</td>
<td>0.5</td>
<td>2.0</td>
<td>(\Omega)</td>
<td>(I_R = 1 \text{ mA}, ; f = 120 \text{ Hz}, ; I_{AC} = 0.1 I_R, ; T_A = +25^\circ C)</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>(e_N)</td>
<td>—</td>
<td>20</td>
<td>—</td>
<td>(\mu V_{RMS})</td>
<td>(I_R = 100 \text{ \mu A}, ; T_A = +25^\circ C, ; 10 \text{ Hz} \leq f \leq 10 \text{ kHz})</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>(\Delta V_R)</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>ppm</td>
<td>(t = 1000 \text{ hrs.}, ; T_A = +25^\circ C, ; \pm 0.1^\circ C, ; I_R = 100 \text{ \mu A})</td>
</tr>
</tbody>
</table>

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance \(\pm (\Delta V_R/\Delta T)(65^\circ C)/(V_R)\). \(\Delta V_R/\Delta T\) is the \(V_R\) temperature coefficient, \(65^\circ C\) is the temperature range from \(-40^\circ C\) to the reference point of \(25^\circ C\), and \(V_R\) is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: \(\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/}^\circ C \times 65^\circ C\)
b. D-grade: \(\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/}^\circ C \times 65^\circ C\)

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of \(\pm 2.5 \times 1.15\% = \pm 29 \text{ mV}\).
### LM4041-ADJ ELECTRICAL CHARACTERISTICS (Note 1)

$T_A = \text{Operating Temperature Range, } T_A = T_J = -40^\circ\text{C to } +85^\circ\text{C, unless noted.}$

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse-Breakdown Voltage</td>
<td>$V_R$</td>
<td>—</td>
<td>1.233</td>
<td>—</td>
<td>V</td>
<td>$I_R = 100 \mu\text{A, } V_{OUT} = 5\text{V}$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Tolerance (Note 2)</td>
<td>—</td>
<td>—</td>
<td>±6.2</td>
<td>mV</td>
<td>$I_R = 100 \mu\text{A, } T_A = +25^\circ\text{C}$</td>
<td></td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>$I_{RMIN}$</td>
<td>—</td>
<td>45</td>
<td>60</td>
<td>$\mu\text{A}$</td>
<td>$T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Reference Voltage Change with Operating Current</td>
<td>$\frac{\Delta V_{REF}}{\Delta I_R}$</td>
<td>—</td>
<td>0.7</td>
<td>1.5</td>
<td>mV</td>
<td>$I_{RMIN} \leq I_R \leq 1 \text{mA, } V_{OUT} \geq 1.6\text{V (Note 3), } T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>2.0</td>
<td></td>
<td></td>
<td>$I_{RMIN} \leq I_R \leq 1 \text{mA, } V_{OUT} \geq 1.6\text{V (Note 3)}$</td>
</tr>
<tr>
<td>Reference Voltage Change with Output Voltage Change</td>
<td>$\frac{\Delta V_{REF}}{\Delta V_O}$</td>
<td>—</td>
<td>−1.55</td>
<td>−2.0</td>
<td>mV/V</td>
<td>$I_R = 1 \text{mA, } T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Feedback Current</td>
<td>$I_{FB}$</td>
<td>—</td>
<td>60</td>
<td>100</td>
<td>nA</td>
<td>$T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Average Reference Voltage Temperature Coefficient</td>
<td>$\frac{\Delta V_{REF}}{\Delta T}$</td>
<td>—</td>
<td>±20</td>
<td>—</td>
<td>ppm/°C</td>
<td>$V_{OUT} = 5\text{V, } I_R = 10 \text{mA, } T_A = +25^\circ\text{C}$</td>
</tr>
<tr>
<td>Dynamic Output Impedance</td>
<td>$Z_{OUT}$</td>
<td>—</td>
<td>0.3</td>
<td>—</td>
<td>$\Omega$</td>
<td>$I_R = 1 \text{mA, } f = 120 \text{Hz, } T_A = +25^\circ\text{C}, I_{AC} = 0.1 I_R, V_{OUT} = \frac{V_{REF}}{1 + (Z_{OUT}/R_{in})}$</td>
</tr>
<tr>
<td>Wideband Noise</td>
<td>$e_N$</td>
<td>—</td>
<td>20</td>
<td>—</td>
<td>$\mu\text{V RMS}$</td>
<td>$I_R = 100 \mu\text{A, } T_A = +25^\circ\text{C, } 10 \text{Hz} \leq f \leq 10 \text{kHz}$</td>
</tr>
</tbody>
</table>

**Note 1:** Specification for packaged product only.

**2:** The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±$((\Delta V_R/\Delta T)(65^\circ\text{C}/V_R))$. $\Delta V_R/\Delta T$ is the $V_R$ temperature coefficient, $65^\circ\text{C}$ is the temperature range from −40°C to the reference point of 25°C, and $V_R$ is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C
b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

**3:** When $V_{OUT} \leq 1.6\text{V}$, the LM4041-ADJ must operate at reduced $I_R$. This is caused by the series resistance of the die attach between the die (-) output and the package (-) output pin. See the Output Saturation curve in the Typical Performance Curves section.
### LM4041-ADJ ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

**T<sub>A</sub>** = Operating Temperature Range, **T<sub>A</sub>** = **T<sub>J</sub>** = -40°C to +85°C, unless noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>∆VR</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>ppm</td>
<td>t = 1000 hrs., <strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C ±0.1°C, <strong>I&lt;sub&gt;R&lt;/sub&gt;</strong> = 100 µA</td>
</tr>
<tr>
<td><strong>LM4041D</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage</td>
<td>VR</td>
<td>—</td>
<td>1.233</td>
<td>—</td>
<td>V</td>
<td><strong>I&lt;sub&gt;R&lt;/sub&gt;</strong> = 100 µA, <strong>V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt;</strong> = 5V</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Tolerance (Note 2)</td>
<td>—</td>
<td>—</td>
<td>±12</td>
<td>—</td>
<td>mV</td>
<td><strong>I&lt;sub&gt;R&lt;/sub&gt;</strong> = 100 µA, <strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>I&lt;sub&gt;MIN&lt;/sub&gt;</td>
<td>—</td>
<td>45</td>
<td>65</td>
<td>µA</td>
<td><strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C</td>
</tr>
<tr>
<td>Reference Voltage Change with Operating Current</td>
<td>∆V&lt;sub&gt;REF&lt;/sub&gt;/∆I&lt;sub&gt;R&lt;/sub&gt;</td>
<td>—</td>
<td>0.7</td>
<td>2.0</td>
<td>mV</td>
<td>**I&lt;sub&gt;MIN&lt;/sub&gt;&lt;/sub&gt; ≤ **I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt; ≤ 1 mA, **V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt; ≤ 1.6V (Note 3), <strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>2.5</td>
<td>—</td>
<td>—</td>
<td>**I&lt;sub&gt;MIN&lt;/sub&gt;&lt;/sub&gt; ≤ **I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt; ≤ 1 mA, **V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt; ≤ 1.6V (Note 3)</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>2.0</td>
<td>6.0</td>
<td>—</td>
<td>—</td>
<td>1 mA ≤ **I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt; ≤ 12 mA, **V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt; ≤ 1.6V (Note 3), <strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>8.0</td>
<td>—</td>
<td>—</td>
<td>1 mA ≤ **I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt; ≤ 12 mA, **V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt; ≤ 1.6V (Note 3)</td>
</tr>
<tr>
<td>Reference Voltage Change with Output Voltage Change</td>
<td>∆V&lt;sub&gt;REF&lt;/sub&gt;/∆V&lt;sub&gt;O&lt;/sub&gt;</td>
<td>—</td>
<td>−1.55</td>
<td>−2.5</td>
<td>mV/V</td>
<td>**I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt; = 1 mA, <strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C</td>
</tr>
<tr>
<td>Feedback Current</td>
<td>I&lt;sub&gt;FB&lt;/sub&gt;</td>
<td>—</td>
<td>60</td>
<td>150</td>
<td>nA</td>
<td><strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C</td>
</tr>
<tr>
<td>Average Reference Voltage Temperature Coefficient</td>
<td>∆V&lt;sub&gt;REF&lt;/sub&gt;/∆T</td>
<td>—</td>
<td>±20</td>
<td>—</td>
<td>ppm/°C</td>
<td>**V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt; = 5V, **I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt; = 10 mA, <strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>±15</td>
<td>±150</td>
<td>—</td>
<td>—</td>
<td>**V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt; = 5V, **I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt; = 1 mA</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>±15</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>**V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt; = 5V, **I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt; = 100 µA, <strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C</td>
</tr>
<tr>
<td>Dynamic Output Impedance</td>
<td>Z&lt;sub&gt;OUT&lt;/sub&gt;</td>
<td>—</td>
<td>0.3</td>
<td>—</td>
<td>Ω</td>
<td>**I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt; = 1 mA, f = 120 Hz, <strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C, **I&lt;sub&gt;AC&lt;/sub&gt;&lt;/sub&gt; = 0.1 **I&lt;sub&gt;R&lt;/sub&gt;&lt;/sub&gt;, **V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt; = **V&lt;sub&gt;REF&lt;/sub&gt;&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>2.0</td>
<td>—</td>
<td>—</td>
<td>**V&lt;sub&gt;OUT&lt;/sub&gt;&lt;/sub&gt; = 10V, <strong>T&lt;sub&gt;A&lt;/sub&gt;</strong> = +25°C</td>
</tr>
</tbody>
</table>

**Note 1:** Specification for packaged product only.

**Note 2:** The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±([∆VR/∆T](65°C)(VR)]. ∆VR/∆T is the VR temperature coefficient, 65°C is the temperature range from -40°C to the reference point of 25°C, and VR is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C
b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

**Note 3:** When **V<sub>OUT</sub></sub> ≤ 1.6V, the LM4041-ADJ must operate at reduced **I<sub>R</sub></sub>. This is caused by the series resistance of the die attach between the die (-) output and the package (-) output pin. See the Output Saturation curve in the Typical Performance Curves section.
**LM4041-ADJ ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)**

$T_A = $ Operating Temperature Range, $T_A = T_J = -40^\circ C$ to $+85^\circ C$, unless noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wideband Noise</td>
<td>$e_N$</td>
<td>—</td>
<td>20</td>
<td>—</td>
<td>$\mu V_{RMS}$</td>
<td>$I_R = 100 \mu A, T_A = +25^\circ C,$ $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$</td>
</tr>
<tr>
<td>Reverse-Breakdown Voltage Long-Term Stability</td>
<td>$\Delta V_R$</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>ppm</td>
<td>$t = 1000 \text{ hrs.}, T_A = +25^\circ C,$ $\pm 0.1^\circ C, I_R = 100 \mu A$</td>
</tr>
</tbody>
</table>

**Note 1:** Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance $\pm ([\Delta V_R/\Delta T](65^\circ C)/(V_R))$. $\Delta V_R/\Delta T$ is the $V_R$ temperature coefficient, $65^\circ C$ is the temperature range from $-40^\circ C$ to the reference point of $25^\circ C$, and $V_R$ is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: $\pm 1.15\% = \pm 0.5\% \pm 100 \text{ ppm/}^\circ C \times 65^\circ C$

b. D-grade: $\pm 1.98\% = \pm 1.0\% \pm 150 \text{ ppm/}^\circ C \times 65^\circ C$

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of $\pm 2.5 \times 1.15\% = \pm 29 \text{ mV}$.

3: When $V_{OUT} \leq 1.6V$, the LM4041-ADJ must operate at reduced $I_R$. This is caused by the series resistance of the die attach between the die (-) output and the package (-) output pin. See the Output Saturation curve in the Typical Performance Curves section.
TEMPERATURE SPECIFICATIONS (Note 1)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Ranges</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>$T_A$</td>
<td>$-40$</td>
<td></td>
<td>+85</td>
<td>°C</td>
<td>—</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>$T_S$</td>
<td>$-65$</td>
<td></td>
<td>+150</td>
<td>°C</td>
<td>—</td>
</tr>
<tr>
<td>Lead Temperature</td>
<td></td>
<td></td>
<td>+215</td>
<td></td>
<td>°C</td>
<td>Vapor phase, 60s</td>
</tr>
<tr>
<td>Lead Temperature</td>
<td></td>
<td></td>
<td>+220</td>
<td></td>
<td>°C</td>
<td>Infrared, 15s</td>
</tr>
<tr>
<td>Package Thermal Resistance</td>
<td></td>
<td></td>
<td></td>
<td>+326</td>
<td>°C/W</td>
<td>—</td>
</tr>
</tbody>
</table>

**Note 1:** The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., $T_A$, $T_J$, $\Theta_{JA}$). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

Test Circuits

**FIGURE 1-1:** LM4040.

**FIGURE 1-2:** LM4041.

**FIGURE 1-3:** Reverse Characteristics Test Circuit.

**FIGURE 1-4:** Output Impedance vs. Frequency Test Circuit.

**FIGURE 1-5:** Large Signal Response Test Circuit.
2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

FIGURE 2-1: LM4040 Output Impedance vs. Frequency.

FIGURE 2-2: LM4040 Output Impedance vs. Frequency.

FIGURE 2-3: LM4040 Reverse Characteristics and Minimum Operating Current.

FIGURE 2-4: LM4040 Noise Voltage vs. Frequency.

FIGURE 2-5: LM4040-2.5 Start-Up Characteristics (RS = 30 kΩ).

FIGURE 2-6: LM4040-5.0 Start-Up Characteristics (RS = 30 kΩ).
FIGURE 2-7: LM4041 Noise Voltage vs. Frequency.

FIGURE 2-8: LM4041 Output Saturation.

FIGURE 2-9: LM4041 Output Impedance vs. Frequency.

FIGURE 2-10: LM4041 Large Signal Response.
### 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

#### TABLE 3-1: PIN FUNCTION TABLE

<table>
<thead>
<tr>
<th>Pin Number Fixed</th>
<th>Pin Number Adjustable</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>+</td>
<td>Cathode. Connect to positive voltage.</td>
</tr>
<tr>
<td>—</td>
<td>1</td>
<td>FB</td>
<td>Feedback. Connect to a resistive divider network to set the output voltage.</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>–</td>
<td>Anode. Connect to negative voltage.</td>
</tr>
<tr>
<td>3</td>
<td>—</td>
<td>NC</td>
<td>Not internally connected. This pin must be left floating or connected to –.</td>
</tr>
</tbody>
</table>
4.0 APPLICATION INFORMATION

The stable operation of the LM4040 and LM4041 references require an external capacitor greater than 10 nF connected between the (+) and (–) pins. Bypass capacitors with values between 100 pF and 10 nF have been found to cause the devices to exhibit instabilities.

4.1 Schottky Diode

LM4040-x.x and LM4041-1.2 in the SOT-23 package have a parasitic Schottky diode between Pin 2 (–) and Pin 3 (die attach interface connect). Pin 3 of the SOT-23 package must float or be connected to Pin 2. The LM4041-ADJ use Pin 3 as the (–) output.

4.2 Conventional Shunt Regulator

In a conventional shunt regulator application (see Figure 5-1), an external series resistor (R_S) is connected between the supply voltage and the LM4040-x.x or LM4041-1.2 reference. R_S determines the current that flows through the load (I_L) and the reference (I_Q). Because load current and supply voltage may vary, R_S should be small enough to supply at least the minimum acceptable I_Q to the reference 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-x.x is less than 15 mA, and the current flowing through the LM4041-1.2 or LM4041-ADJ is less than 12 mA.

R_S is determined by the supply voltage (V_S), the load and operating current (I_L and I_Q), and the reference’s reverse breakdown voltage (V_R):

\[
R_S = \frac{(V_S - V_R)}{(I_L + I_Q)}
\]

4.3 Adjustable Regulator

The LM4041-ADJ’s output voltage can be adjusted to any value between 1.24V and 10V. It is a function of the internal reference voltage (V_REF) and the ratio of the external feedback resistors as shown in Figure 5-2. The output is found using the following equation:

\[
V_O = V_{REF}[(R2/R1) + 1]
\]

Where:

- \(V_O\) Desired Output Voltage

The actual value of the internal V_REF is a function of V_O. The corrected V_REF is determined by:

EQUATION 4-3:

\[
V_{REF} = V_O \times \left(\frac{\Delta V_{REF}}{\Delta V_O}\right) + V_Y
\]

Where:

- \(V_O\) Desired Output Voltage

\(\Delta V_{REF}/\Delta V_O\) is found in the Electrical Characteristics section and is typically –1.3 mV/V and \(V_Y\) is equal to 1.233V. Replace the value of V_REF in Equation 4-2 with the value V_REF found using Equation 4-3.

Note that actual output voltage can deviate from that predicted using the typical \(\Delta V_{REF}/\Delta V_O\) in Equation 4-3; for C-grade parts, the worst case \(\Delta V_{REF}/\Delta V_O\) is –2.5 mV/V and \(V_Y = 1.248V\).

The following example shows the difference in output voltage resulting from the typical and worst case values of \(\Delta V_{REF}/\Delta V_O\).

Let \(V_O = +9V\). Using the typical values of \(\Delta V_{REF}/\Delta V_O\), \(V_{REF}\) is 1.223V. Choosing a value of \(R1 = 10 \, k\Omega\), \(R2 = 63.272 \, k\Omega\). Using the worst case \(\Delta V_{REF}/\Delta V_O\) for the C-grade and D-grade parts, the output voltage is actually 8.965V and 8.946V respectively. This results in possible errors as large as 0.39% for the C-grade parts and 0.59% for the D-grade parts. Once again, resistor values found using the typical value of \(\Delta V_{REF}/\Delta V_O\) will work in most cases, requiring no further adjustment.
5.0 TYPICAL APPLICATION CIRCUITS

**FIGURE 5-1:** Voltage Level Detector.

**FIGURE 5-2:** Voltage Level Detector.

**FIGURE 5-3:** Fast Positive Clamp, $2.4V + \Delta V_{D1}$. 

**FIGURE 5-4:** Bidirectional Clamp ±2.4V.

**FIGURE 5-5:** Bidirectional Adjustable Clamp ±1.8V to ±2.4V.

**FIGURE 5-6:** Bidirectional Adjustable Clamp ±2.4V to ±6V.
**FIGURE 5-7:** Floating Current Detector.

\[
I_{\text{Threshold}} = \frac{1.24V}{R1} + \frac{5A}{4N28 \text{ GAIN}} = 3.2mA
\]

*D1 can be any LED, \( V_F = 1.5V \) to 2.2V at 3mA. D1 may act as an indicator. D1 will be on if \( I_{\text{Threshold}} \) falls below the threshold current, except with \( I = 0 \).*

**FIGURE 5-8:** Current Source.

\[
I_{\text{OUT}} = \frac{1.24V}{R1}
\]

\[
1A < I_{\text{OUT}} = 100mA
\]

**FIGURE 5-9:** Precision Floating Current Detector.

\[
I_{\text{Threshold}} = \frac{1.24V}{R1} = 3.7mA \pm 2%
\]

*D1 can be any LED, \( V_F = 1.5V \) to 2.2V at 3mA. D1 may act as an indicator. D1 will be on if \( I_{\text{Threshold}} \) falls below the threshold current, except with \( I = 0 \).*
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

3-Pin SOT-23*

<table>
<thead>
<tr>
<th>Device</th>
<th>Top Side Marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM4040CYM3-2.5-TR</td>
<td>Y2C</td>
</tr>
<tr>
<td>LM4040CYM3-4.1-TR</td>
<td>Y4C</td>
</tr>
<tr>
<td>LM4040CYM3-5.0-TR</td>
<td>Y5C</td>
</tr>
<tr>
<td>LM4040DYM3-2.5-TR</td>
<td>Y2D</td>
</tr>
<tr>
<td>LM4040DYM3-4.1-TR</td>
<td>Y4D</td>
</tr>
<tr>
<td>LM4040DYM3-5.0-TR</td>
<td>Y5D</td>
</tr>
<tr>
<td>LM4041CYM3-ADJ-TR</td>
<td>YAC</td>
</tr>
<tr>
<td>LM4041DYM3-1.2-TR</td>
<td>Y1C</td>
</tr>
<tr>
<td>LM4041DYM3-ADJ-TR</td>
<td>Y1D</td>
</tr>
</tbody>
</table>

Legend: XX...X Product code or customer-specific information
        Y Year code (last digit of calendar year)
        YY Year code (last 2 digits of calendar year)
        WW Week code (week of January 1 is week ’01’)
        NNN Alphanumeric traceability code
        e3 Pb-free JEDEC® designator for Matte Tin (Sn)
        * This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.
        ●, ▲, ▼ Pin one index is identified by a dot, delta up, or delta down (triangle mark).

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) and/or Overbar (‘) symbol may not be to scale.
3-Lead SOT-23 Package Outline and Recommended Land Pattern

NOTE:
1. All dimensions are in millimeters.
2. Package surface to be matte finish VDI 11-13.
3. Die is facing up for mold & trim/form.
   ▶ Dimension are exclusive mold flash and gate burr.
   ▶ Dimension are exclusive solder plating.

Recommended Land Pattern

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.
APPENDIX A: REVISION HISTORY

Revision A (April 2017)

• Converted Micrel data sheet LM4040/LM4041 to Microchip DS20005757A.
• Minor text changes throughout.
• Updated temperature information in all Electrical Characteristics tables to better reflect which values are valid for $T_A = +25^\circ C$.

Revision B (July 2018)

• Corrected part number for Reverse Current in Operating Ratings $\dagger$ to LM4041-ADJ.
• Updated Section 6.1 “Package Marking Information” drawing and information.
• Updated information in Product Identification System.
• Updated “Reverse-Breakdown Voltage Change with Operating Current Change” conditions for LM4041-1.2 Electrical Characteristics (Note 1) and LM4041-ADJ Electrical Characteristics (Note 1).
# PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

### Examples:

<table>
<thead>
<tr>
<th>PART NO.</th>
<th>Device</th>
<th>Accuracy, Temperature Coefficient</th>
<th>Temperature Range</th>
<th>Package</th>
<th>Voltage</th>
<th>Media Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM4040CYM3-2.5-TR</td>
<td>LM4040: Precision Micropower Shunt Voltage Reference</td>
<td>±0.5%, 100 ppm/°C</td>
<td>–40°C to +85°C Temp. Range</td>
<td>3-Lead SOT-23</td>
<td>2.500V</td>
<td>3,000/Reel</td>
</tr>
<tr>
<td>LM4040DYM3-2.5-TR</td>
<td>LM4041: Precision Micropower Shunt Voltage Reference</td>
<td>±1.0%, 150 ppm/°C</td>
<td>–40°C to +85°C Temp. Range</td>
<td>3-Lead SOT-23</td>
<td>1.24V to 10V</td>
<td>3,000/Reel</td>
</tr>
<tr>
<td>LM4040CYM3-4.1-TR</td>
<td>LM4040: Precision Micropower Shunt Voltage Reference</td>
<td>±0.5%, 100 ppm/°C</td>
<td>–40°C to +85°C Temp. Range</td>
<td>3-Lead SOT-23</td>
<td>4.096V</td>
<td>3,000/Reel</td>
</tr>
<tr>
<td>LM4040DYM3-4.1-TR</td>
<td>LM4041: Precision Micropower Shunt Voltage Reference</td>
<td>±1.0%, 150 ppm/°C</td>
<td>–40°C to +85°C Temp. Range</td>
<td>3-Lead SOT-23</td>
<td>4.096V</td>
<td>3,000/Reel</td>
</tr>
<tr>
<td>LM4040CYM3-5.0-TR</td>
<td>LM4040: Precision Micropower Shunt Voltage Reference</td>
<td>±0.5%, 100 ppm/°C</td>
<td>–40°C to +85°C Temp. Range</td>
<td>3-Lead SOT-23</td>
<td>5.000V</td>
<td>3,000/Reel</td>
</tr>
<tr>
<td>LM4040DYM3-5.0-TR</td>
<td>LM4041: Precision Micropower Shunt Voltage Reference</td>
<td>±1.0%, 150 ppm/°C</td>
<td>–40°C to +85°C Temp. Range</td>
<td>3-Lead SOT-23</td>
<td>5.000V</td>
<td>3,000/Reel</td>
</tr>
<tr>
<td>LM4041CYM3-1.2-TR</td>
<td>LM4041: Precision Micropower Shunt Voltage Reference</td>
<td>±0.5%, 100 ppm/°C</td>
<td>–40°C to +85°C Temp. Range</td>
<td>3-Lead SOT-23</td>
<td>1.225V</td>
<td>3,000/Reel</td>
</tr>
<tr>
<td>LM4041DYM3-1.2-TR</td>
<td>LM4041: Precision Micropower Shunt Voltage Reference</td>
<td>±1.0%, 150 ppm/°C</td>
<td>–40°C to +85°C Temp. Range</td>
<td>3-Lead SOT-23</td>
<td>1.225V</td>
<td>3,000/Reel</td>
</tr>
</tbody>
</table>

### Note 1:
Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.
Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip’s Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip’s code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer’s risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademark
The Microchip name and logo, the Microchip logo, AnyRate, AVR, AVR logo, AVR Freaks, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, Heldo, JukeBlox, Keeloq, Kleer, LANCheck, LINK MD, maxXStylus, maxTouch, MediaLB, megaAVR, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picPower, PICSTART, PIC32 logo, Prochip Designer, QTouch, SAM-BA, SpyNic, SST, SST Logo, SuperFlash, tinyAVR, UNI/O, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, EtherSynch, Hyper Speed Control, HyperLight Load, IntellIMOS, mTouch, Precision Edge, and Quiet-Wire are registered trademarks of Microchip Technology Incorporated in the U.S.A.


SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc., in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2017-2018, Microchip Technology Incorporated, All Rights Reserved.

**Worldwide Sales and Service**

### AMERICAS

**Corporate Office**
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277

Technical Support: [http://www.microchip.com/support](http://www.microchip.com/support)

Web Address: [www.microchip.com](http://www.microchip.com)

**Atlanta**
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

**Austin, TX**
Tel: 512-257-3370

**Boston**
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

**Chicago**
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

**Dallas**
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

**Detroit**
Novi, MI
Tel: 248-848-4000

**Houston, TX**
Tel: 281-894-5983

**Indianapolis**
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

**Los Angeles**
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

**Raleigh, NC**
Tel: 919-844-7510

**New York, NY**
Tel: 631-435-6000

**San Jose, CA**
Tel: 408-735-9110
Tel: 408-436-4270

**Canada - Toronto**
Tel: 905-695-1980
Fax: 905-695-2078

### ASIA/PACIFIC

**Australia - Sydney**
Tel: 61-2-9886-6733

**China - Beijing**
Tel: 86-10-8569-7000

**China - Chengdu**
Tel: 86-28-8665-5511

**China - Chongqing**
Tel: 86-23-8880-9588

**China - Dongguan**
Tel: 86-769-8702-9880

**China - Guangzhou**
Tel: 86-20-8755-8029

**China - Hangzhou**
Tel: 86-571-8792-8115

**China - Hong Kong SAR**
Tel: 852-2943-5100

**China - Nanjing**
Tel: 86-25-8473-2460

**China - Qingdao**
Tel: 86-532-8502-7355

**China - Shanghai**
Tel: 86-21-3326-8000

**China - Shenyang**
Tel: 86-24-2334-2829

**China - Shenzhen**
Tel: 86-755-8884-2200

**China - Suzhou**
Tel: 86-186-6233-1526

**China - Wuhan**
Tel: 86-27-5980-5300

**China - Xian**
Tel: 86-29-8833-7252

**China - Xiamen**
Tel: 86-592-2386138

**China - Zuhai**
Tel: 86-756-3210040

**India - Bangalore**
Tel: 91-80-3090-4444

**India - New Delhi**
Tel: 91-11-4160-8631

**India - Pune**
Tel: 91-20-4121-0141

**Japan - Osaka**
Tel: 81-6-6152-7160

**Japan - Tokyo**
Tel: 81-3-6880-3770

**Korea - Daegu**
Tel: 82-53-744-4301

**Korea - Seoul**
Tel: 82-2-554-7200

**Malaysia - Kuala Lumpur**
Tel: 60-3-7651-7906

**Malaysia - Penang**
Tel: 60-4-227-8870

**Philippines - Manila**
Tel: 63-2-634-9065

**Singapore**
Tel: 65-6334-8870

**Taiwan - Hsin Chu**
Tel: 886-3-577-8366

**Taiwan - Kaohsiung**
Tel: 886-7-213-7830

**Taiwan - Taipei**
Tel: 886-2-2508-8600

**Thailand - Bangkok**
Tel: 66-2-694-1351

**Vietnam - Ho Chi Minh**
Tel: 84-8-5448-2100

### ASIA/PACIFIC

**Europe**

**Austria - Wels**
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

**Denmark - Copenhagen**
Tel: 45-4450-2828
Fax: 45-4485-2829

**Finland - Espoo**
Tel: 358-9-4520-820

**France - Paris**
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

**Germany - Garching**
Tel: 49-8931-9700

**Germany - Haan**
Tel: 49-2129-3766400

**Germany - Heilbronn**
Tel: 49-7131-67-3636

**Germany - Karlsruhe**
Tel: 49-721-625370

**Germany - Munich**
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

**Germany - Rosenheim**
Tel: 49-8031-354-560

**Israel - Ra’anana**
Tel: 972-9-744-7705

**Italy - Milan**
Tel: 39-0331-742611
Fax: 39-0331-466781

**Italy - Padova**
Tel: 39-049-7625286

**Netherlands - Drunen**
Tel: 31-416-690399
Fax: 31-416-690340

**Norway - Trondheim**
Tel: 47-7289-7561

**Poland - Warsaw**
Tel: 48-22-3325737

**Romania - Bucharest**
Tel: 40-21-407-87-50

**Spain - Madrid**
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

**Sweden - Gothenburg**
Tel: 46-31-708-60-40

**Sweden - Stockholm**
Tel: 46-8-5090-4654

**UK - Wokingham**
Tel: 44-118-921-5800
Fax: 44-118-921-5820