LTC6078/LTC6079
Micropower Precision, Dual/Quad CMOS Rail-to-Rail Input/Output Amplifiers

FEATURES
- Maximum Offset Voltage of 25µV (25°C)
- Maximum Offset Drift of 0.7µV/°C
- Maximum Input Bias:
  1µA (25°C)
  50pA (≤85°C)
- Micropower: 54µA per Amp
- 95dB CMRR (Min)
- 100dB PSRR (Min)
- Input Noise Voltage Density: 16nV/√Hz
- Rail-to-Rail Inputs and Outputs
- 2.7V to 5.5V Operation Voltage
- LTC6078 Available in 8-Lead MSOP and 10-Lead DFN Packages; LTC6079 Available in 16-Lead SSOP and DFN Packages

APPLICATIONS
- Photodiode Amplifier
- High Impedance Sensor Amplifier
- Microvolt Accuracy Threshold Detection
- Instrumentation Amplifiers
- Battery Powered Applications

DESCRIPTION
The LTC®6078/LTC6079 are dual/quad, low offset, low noise operational amplifiers with low power consumption and rail-to-rail input/output swing.

Input offset voltage is trimmed to less than 25µV and the CMOS inputs draw less than 50pA of bias current. The low offset drift, excellent CMRR, and high voltage gain make it a good choice for precision signal conditioning.

Each amplifier draws only 54µA current on a 3V supply. The micropower, rail-to-rail operation of the LTC6078/LTC6079 is well suited for portable instruments and single supply applications.

The LTC6078/LTC6079 are specified on power supply voltages of 3V and 5V from –40 to 125°C. The dual amplifier LTC6078 is available in 8-lead MSOP and 10-lead DFN packages. The quad amplifier LTC6079 is available in 16-lead SSOP and DFN packages.

**TYPICAL APPLICATION**

**Thermocouple Signal Conditioner**

**V_{OS} Distribution**

**NUMBER OF AMPS OUT OF 28**

**V_{OS} (µV)**

- LTC6078MS8
- V_{IN} = 2V
- V_{OS} = 0.5V
- T_{A} = 25°C

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Linear Technology Corporation. All other trademarks are the property of their respective owners. Patent Pending.
ABSOLUTE MAXIMUM RATINGS
(Note 1)
Total Supply Voltage (V+ to V–) ................................... 6V
Input Voltage ........................................................ V– to V+
Output Short Circuit Duration (Note 2) ............ Indefinite
Operating Temperature Range (Note 3)
LTC6078C, LTC6079C ........................................ –40°C to 85°C
LTC6078I, LTC6079I ........................................ –40°C to 85°C
LTC6078H, LTC6079H ........................................ –40°C to 125°C
(Not Available in DFN Package)

Specified Temperature Range (Note 4)
LTC6078C, LTC6079C ........................................ 0°C to 70°C
LTC6078I, LTC6079I ........................................ –40°C to 85°C
LTC6078H, LTC6079H ........................................ –40°C to 125°C

Junction Temperature
DFN Packages ................................................... 125°C
All Other Packages ............................................ 150°C

Storage Temperature Range
DFN Packages .................................... –65°C to 125°C
All Other Packages ............................. –65°C to 150°C

Lead Temperature (Soldering, 10 Sec) .................. 300°C

PACKAGE/OPT ORDER INFORMATION

ORDER PART
NUMBER
LTC6078CDHCPBF
LTC6078IDHCPBF
LTC6078ACMS8PBF
LTC6078CMS8PBF
LTC6078AIMS8PBF
LTC6078IMS8PBF
LTC6078AHMS8PBF
LTC6078HMS8PBF
LTC6079CDHC
LTC6079IDHC
LTC6079ACMS8
LTC6079CMS8
LTC6079AIMS8
LTC6079IMS8
LTC6079AHMS8
LTC6079HMS8
LTC6079CGN
LTC6079IGN
LTC6079HGN

ORDER PART
NUMBER
LTC6078CDD
LTC6078IDD
LTC6078ACMS8
LTC6078CMS8
LTC6078AIMS8
LTC6078IMS8
LTC6078AHMS8
LTC6078HMS8
LTC6079CDHC
LTC6079IDHC
LTC6079ACMS8
LTC6079CMS8
LTC6079AIMS8
LTC6079IMS8
LTC6079AHMS8
LTC6079HMS8
LTC6079CGN
LTC6079IGN
LTC6079HGN

DD PART
MARKING*
LBBB
LBBB
LTAJZ
LTAJZ
LTAJZ
LTAJZ
LTAJZ
LTAJZ
LTAJZ
LTAJZ
6079
6079
6079
6079

Order Options
Tape and Reel: Add #TR
Lead Free: Add #PBF  Lead Free Tape and Reel: Add #TRPBF
Lead Free Part Marking: http://www.linear.com/leadfree/

Consult LTC Marketing for parts specified with wider operating temperature ranges.
* The temperature grades and parametric grades are identified by a label on the shipping container.
### Electrical Characteristics

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at TA = 25°C. Test conditions are V+ = 3V, V− = 0V, VCM = 0.5V unless otherwise noted.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>C, I SUFFIXES</th>
<th>H SUFFIX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOS</td>
<td>Offset Voltage (Note 5)</td>
<td>LTC6078MS8, LTC6078AMS8, LTC6079GN</td>
<td>● ±7</td>
<td>±7</td>
<td>μV</td>
</tr>
<tr>
<td></td>
<td>● ±20</td>
<td>±25</td>
<td>±25</td>
<td>μV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● ±25</td>
<td>±20</td>
<td>±25</td>
<td>μV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● ±30</td>
<td>±20</td>
<td>±70</td>
<td>μV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● ±30</td>
<td>±25</td>
<td>±95</td>
<td>μV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● ±30</td>
<td>±30</td>
<td>±135</td>
<td>μV</td>
<td></td>
</tr>
<tr>
<td>ΔVOS/ΔT</td>
<td>Input Offset Voltage Drift (Note 5)</td>
<td>LTC6078AMS8</td>
<td>● ±0.2</td>
<td>±0.2</td>
<td>μV/°C</td>
</tr>
<tr>
<td></td>
<td>● ±0.3</td>
<td>±0.7</td>
<td>μV/°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● ±0.1</td>
<td>±0.1</td>
<td>μV/°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● ±0.3</td>
<td>±1.4</td>
<td>μV/°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● ±0.3</td>
<td>±1.8</td>
<td>μV/°C</td>
<td></td>
<td></td>
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<tr>
<td>IB</td>
<td>Input Bias Current (Note 6)</td>
<td>VCM = V+/2</td>
<td>● 0.2</td>
<td>0.2</td>
<td>pA</td>
</tr>
<tr>
<td></td>
<td>● 0.3</td>
<td>0.3</td>
<td>150</td>
<td>pA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● 0.5</td>
<td>0.5</td>
<td>350</td>
<td>pA</td>
<td></td>
</tr>
<tr>
<td>IDSS</td>
<td>Input Offset Current (Note 6)</td>
<td>VCM = V+/2</td>
<td>● 0.1</td>
<td>0.1</td>
<td>pA</td>
</tr>
<tr>
<td></td>
<td>● 0.5</td>
<td>0.5</td>
<td>10</td>
<td>pA</td>
<td></td>
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<tr>
<td>εn</td>
<td>Input Noise Voltage 0.1Hz to 10Hz</td>
<td>1</td>
<td>1</td>
<td>μV P-P</td>
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<tr>
<td></td>
<td>Input Noise Voltage Density f = 1kHz</td>
<td>18</td>
<td>18</td>
<td>nV/√Hz</td>
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<tr>
<td></td>
<td>f = 10kHz</td>
<td>16</td>
<td>16</td>
<td>nV/√Hz</td>
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<tr>
<td>IN</td>
<td>Input Noise Current Density (Note 8)</td>
<td>0.56</td>
<td>0.56</td>
<td>fA/√Hz</td>
<td></td>
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<tr>
<td>CDIFF</td>
<td>Differential Input Capacitance</td>
<td></td>
<td>10</td>
<td>10</td>
<td>pF</td>
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<tr>
<td>CCM</td>
<td>Common Mode Input Capacitance</td>
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<td>18</td>
<td>18</td>
<td>pF</td>
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<tr>
<td>CMRR</td>
<td>Common Mode Rejection Ratio</td>
<td>All Packages</td>
<td>95</td>
<td>95</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>● 85</td>
<td>85</td>
<td>110</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● 89</td>
<td>89</td>
<td>103</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● 84</td>
<td>84</td>
<td>102</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>PSRR</td>
<td>Power Supply Rejection Ratio</td>
<td>V+ = 2.7V to 5.5V</td>
<td>● 100</td>
<td>100</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>97</td>
<td>97</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>VOUT</td>
<td>Output Voltage, High (Referred to V+)</td>
<td>No Load</td>
<td>● 35</td>
<td>35</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● 1</td>
<td>1</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>● 350</td>
<td>350</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output Voltage, Low (Referred to V−)</td>
<td>No Load</td>
<td>● 1</td>
<td>1</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● 10</td>
<td>10</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>● 30</td>
<td>30</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>● 300</td>
<td>300</td>
<td>mV</td>
<td></td>
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<tr>
<td>AVOL</td>
<td>Large-Signal Voltage Gain</td>
<td>RL = 10k, 0.5V ≤ VOUT ≤ 2.5V</td>
<td>● 115</td>
<td>115</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130</td>
<td>130</td>
<td>dB</td>
<td></td>
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<tr>
<td>ISC</td>
<td>Output Short-Circuit Current</td>
<td>Source</td>
<td>● 5</td>
<td>5</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>10</td>
<td>mA</td>
<td></td>
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<td></td>
<td>Sink</td>
<td>● 7</td>
<td>7</td>
<td>mA</td>
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<td></td>
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<td>14</td>
<td>14</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>SR</td>
<td>Slew Rate</td>
<td>AV = 1</td>
<td>0.05</td>
<td>0.05</td>
<td>μV/μs</td>
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<tr>
<td>GBW</td>
<td>Gain-Bandwidth Product (fTEST = 10kHz)</td>
<td>RL = 10k</td>
<td>420</td>
<td>420</td>
<td>kHz</td>
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<td></td>
<td></td>
<td>750</td>
<td>750</td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>360</td>
<td>360</td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>320</td>
<td>320</td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td>φ0</td>
<td>Phase Margin</td>
<td>RL = 10k, CL = 200pF</td>
<td>66</td>
<td>66</td>
<td>Deg</td>
</tr>
<tr>
<td>TS</td>
<td>Settling Time 0.1%</td>
<td>AV = 1, 1V Step</td>
<td>24</td>
<td>24</td>
<td>μs</td>
</tr>
</tbody>
</table>
## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ C$. Test conditions are $V^+ = 3V$, $V^- = 0V$, $V_{CM} = 0.5V$ unless otherwise noted.

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</tr>
</thead>
<tbody>
<tr>
<td>$I_S$</td>
<td>Supply Current (per Amplifier)</td>
<td>No Load</td>
<td>●</td>
<td>54</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>0.3</td>
<td>1</td>
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<tr>
<td>$V_S$</td>
<td>Supply Voltage Range</td>
<td>Guaranteed by the PSRR Test</td>
<td>●</td>
<td>2.7</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>2.7</td>
<td>5.5</td>
</tr>
<tr>
<td>$I_{SHDN}$</td>
<td>Shutdown Current (per Amplifier)</td>
<td>SHDN High, LTC6078DD</td>
<td>●</td>
<td>2</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>2</td>
<td>0.8</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>0.6</td>
<td>0.6</td>
</tr>
</tbody>
</table>

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ C$. Test conditions are $V^+ = 5V$, $V^- = 0V$, $V_{CM} = 0.5V$ unless otherwise noted.

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<th>H SUFFIX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DS}$</td>
<td>Offset Voltage</td>
<td>LTC6078MS8, LTC6078AMS8, LTC6079GN</td>
<td>●</td>
<td>±10</td>
<td>±10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LTC6078DD, LTC6079DHC</td>
<td>●</td>
<td>±10</td>
<td>±10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LTC6078AMS8</td>
<td>●</td>
<td>±20</td>
<td>±20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LTC6078MS8</td>
<td>●</td>
<td>±25</td>
<td>±25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LTC6079GN</td>
<td>●</td>
<td>±30</td>
<td>±30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LTC6079DD</td>
<td>●</td>
<td>±35</td>
<td>±35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LTC6079DHC</td>
<td>●</td>
<td>±35</td>
<td>±35</td>
</tr>
</tbody>
</table>

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ C$. Test conditions are $V^+ = 5V$, $V^- = 0V$, $V_{CM} = 0.5V$ unless otherwise noted.

<table>
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<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_B$</td>
<td>Input Bias Current</td>
<td>$V_{CM} = V^+/2$</td>
<td>●</td>
<td>0.2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{CM} = V^-/2$</td>
<td>●</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>$I_{OS}$</td>
<td>Input Offset Current</td>
<td>$V_{CM} = V^+/2$</td>
<td>●</td>
<td>0.1</td>
<td>0.1</td>
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<tr>
<td></td>
<td></td>
<td>$V_{CM} = V^-/2$</td>
<td>●</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td>$e_n$</td>
<td>Input Noise Voltage</td>
<td>0.1Hz to 10Hz</td>
<td>1</td>
<td>1</td>
<td>μV</td>
</tr>
</tbody>
</table>
## ELECTRICAL CHARACTERISTICS

The ** symbol denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ\text{C}$. Test conditions are $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 0.5\text{V}$ unless otherwise noted.

### SYMBOL | PARAMETER | CONDITIONS | C, I SUFFIXES | H SUFFIX | UNITS
--- | --- | --- | --- | --- | ---
CMRR | Common Mode Rejection Ratio | All Packages $V_{CM} = 0\text{V to 5V}$ | 91 105 | 91 105 | dB
| LTC6078AMS8 $V_{CM} = 0\text{V to 5V}$ | 90 105 | 90 105 | dB
| LTC6078MS8 $V_{CM} = 0\text{V to 3.7V}$ | 94 105 | 94 105 | dB
| LTC6078MS8 $V_{CM} = 0\text{V to 5V}$ | 88 100 | 88 100 | dB
| LTC6079GN $V_{CM} = 0\text{V to 5V}$ | 90 105 | 90 105 | dB
| LTC6079GN $V_{CM} = 0\text{V to 3.7V}$ | 86 100 | 86 100 | dB
| LTC6078DD, LTC6079DHC $V_{CM} = 0\text{V to 5V}$ | 90 105 | 90 105 | dB
| LTC6078DD, LTC6079DHC $V_{CM} = 0\text{V to 3.7V}$ | 86 100 | 86 100 | dB

PSRR | Power Supply Rejection Ratio | $V_S = 2.7\text{V to 5.5V}$ | 100 120 | 97 97 | dB

V<sub>OUT</sub> | Output Voltage, High (Referred to $V^+$) | No Load $I_{\text{SOURCE}} = 0.5\text{mA}$ | 2 | 2 | mV
| LTC6078AMS8 $V_{CM} = 0\text{V to 3.7V}$ | 50 20 | 55 20 | mV
| LTC6078MS8 $V_{CM} = 0\text{V to 5V}$ | 500 200 | 550 200 | mV

Output Voltage, Low (Referred to $V^+$) | No Load $I_{\text{SINK}} = 0.5\text{mA}$ | 1 | 1 | mV
| LTC6078AMS8 $V_{CM} = 0\text{V to 3.7V}$ | 15 40 | 15 45 | mV
| LTC6078MS8 $V_{CM} = 0\text{V to 5V}$ | 150 400 | 150 450 | mV

$A_{VOL}$ | Large-Signal Voltage Gain | $R_{LOAD} = 10k, 0.5V \leq V_{\text{OUT}} \leq 4.5V$ | 115 130 | 110 125 | dB

$\phi_S$ | Source Slew Rate | $R_L = 10k, C_L = 200\text{pF}$ | 66 | 66 | Deg

$V_S$ | Supply Voltage Range Guaranteed by the PSRR Test | $f_s = 10kHz$, $R_L = 10k$ | 2.7 5.5 | 2.7 5.5 | V

Channel Separation | $f_s = 10kHz$, $R_L = 10k$ | -110 | -110 | dB

Shutdown Logic | SHDN High, LTC6078DD | 3.5 3.5 | 2.7 2.7 | V
| SHDN Low, LTC6078DD | | 3.5 3.5 | 2.7 2.7 | V

$V_{\text{SHDN}}$ | Turn on Time | $V_{\text{SHDN}} = 1.2\text{V to 3.5V}, \text{LTC6078DD}$ | 50 | 50 | µs

$V_{\text{SHDN}}$ | Turn off Time | $V_{\text{SHDN}} = 1.2\text{V to 3.5V}, \text{LTC6078DD}$ | 2 | 2 | µs

Leakage of SHDN Pin | | | 0.6 | | µA

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**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**Note 2:** A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted.

**Note 3:** The LTC6078C/LTC6079C and LTC6078I/LTC6079I are guaranteed functional over the operating temperature range of $–40^\circ\text{C to 85^\circC}$, The LTC6078H/LTC6079H are guaranteed functional over the operating temperature range of $–40^\circ\text{C to 125^\circC}$.

**Note 4:** The LTC6078C/LTC6079C are guaranteed to meet specified performance from $0^\circ\text{C to 70^\circC}$. The LTC6078C/LTC6079C are designed, characterized and expected to meet specified performance from $–40^\circ\text{C to 85^\circC}$ but are not tested or QA sampled at these temperatures. The LTC6078I/LTC6079I are guaranteed to meet specified performance from $–40^\circ\text{C to 85^\circC}$.

**Note 5:** $V_{\text{OS}}$ and $V_{\text{OS}}$ drift are 100% tested at $25^\circ\text{C}$ and $125^\circ\text{C}$.

**Note 6:** $I_{B}$ and $I_{OS}$ are guaranteed by the $V_S = 5\text{V}$ test.

**Note 7:** $V_{\text{OS}}$ drift is guaranteed by the $V_S = 3\text{V}$ test.

**Note 8:** Current noise is calculated from $I_{n} = \sqrt{2qI_B}$, where $q = 1.6 \cdot 10^{-19}$ coulomb.
### TYPICAL PERFORMANCE CHARACTERISTICS

#### PIN FUNCTIONS

<table>
<thead>
<tr>
<th>PIN</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT</td>
<td>Amplifier Output</td>
</tr>
<tr>
<td>–IN</td>
<td>Inverting Input</td>
</tr>
<tr>
<td>+IN</td>
<td>Noninverting Input</td>
</tr>
<tr>
<td>V+:</td>
<td>Positive Supply</td>
</tr>
<tr>
<td>V–:</td>
<td>Negative Supply</td>
</tr>
</tbody>
</table>

**SHDN_A**: Shutdown Pin of Amplifier A, active low and only valid for LTC6078DD. An internal current source pulls the pin to V+ when floating.

**SHDN_B**: Shutdown Pin of Amplifier B, active low and only valid for LTC6078DD. An internal current source pulls the pin to V+ when floating.

**NC**: Not internally connected.

**Exposed Pad**: Connected to V–.
Applications Information

Preserving Input Precision

Preserving input accuracy of the LTC6078/LTC6079 requires that the application circuit and PCB board layout do not introduce errors comparable or greater than the 10µV typical offset of the amplifiers. Temperature differentials across the input connections can generate thermocouple voltages of 10’s of microvolts so the connections to the input leads should be short, close together and away from heat dissipating components. Air current across the board can also generate temperature differentials.

The extremely low input bias currents (0.2pA typical) allow high accuracy to be maintained with high impedance sources and feedback resistors. Leakage currents on the PCB board can be higher than the input bias current. For example, 10GΩ of leakage between a 5V supply lead and an input lead will generate 500pA! Surround the input leads with a guard ring driven to the same potential as the input common mode to avoid excessive leakage in high impedance applications.

Input Clamps

Large differential voltages across the inputs over very long time periods can impact the precisely trimmed input offset voltage of the LTC6078/LTC6079. As an example, a 2V differential voltage between the inputs over a period of 100 hours can shift the input offset voltage by tens of microvolts. If the amplifier is to be subjected to large differential input voltages, adding back-to-back diodes between the two inputs will minimize this shift and retain the DC precision. If necessary, current-limiting series resistors can be added in front of the diodes, as shown in Figure 1. These diodes are not necessary for normal closed loop applications.

Figure 1. Op Amp with Input Voltage Clamp

Capacitive Load

LTC6078/LTC6079 can drive capacitive load up to 200pF in unity gain. The capacitive load driving capability increases as the amplifier is used in higher gain configurations. A small series resistance between the output and the load further increases the amount of capacitance the amplifier can drive.

SHDN Pins

Pins 5 and 6 are used for power shutdown on the LTC6078 in the DD package. If they are floating, internal current sources pull Pins 5 and 6 to V+ and the amplifiers operate normally. In shutdown, the amplifier output is high impedance, and each amplifier draws less than 2µA current.

When the chip is turned on, the supply current per amplifier is about 35µA larger than its normal values for 50µs.

Rail-to-Rail Input

The input stage of LTC6078/LTC6079 combines both PMOS and NMOS differential pairs, extending its input common mode voltage range to both positive and negative supply voltages. At high input common mode range, the NMOS pair is on. At low common mode range, the PMOS pair is on. The transition happens when the common voltage is between 1.3V and 0.9V below the positive supply.

Thermal Hysteresis

Figure 2 shows the input offset hysteresis of LTC6078MS8 for 3 thermal cycles from –45°C to 90°C. The typical offset shift after the 3 cycles is only 1µV.

Figure 2. VOS Thermal Hysteresis of LTC6078MS8

![Figure 2. VOS Thermal Hysteresis of LTC6078MS8](image)
APPLICATIONS INFORMATION

PC Board Layout

Mechanical stress on a PC board and soldering-induced stress can cause the $V_{OS}$ and $V_{OS}$ drift to shift. The DD and DHC packages are more sensitive to stress. A simple way to reduce the stress-related shifts is to mount the IC near the short edge of the PC board, or in a corner. The board edge acts as a stress boundary, or a region where the flexure of the board is minimum. The package should always be mounted so that the leads absorb the stress and not the package. The package is generally aligned with the leads parallel to the long side of the PC board.

The most effective technique to relieve the PC board stress is to cut slots in the board around the op amp. These slots can be cut on three sides of the IC and the leads can exit on the fourth side. Figure 3 shows the layout of a LTC6078DD with slots at three sides.

![Figure 3. Vertical Orientation of LTC6078DD with Slots](image)

SIMPLIFIED SCHEMATIC

Simplified Schematic of the Amplifier

NOTE: SHDN is only available in the DFN10 package
TYPICAL APPLICATIONS

2.7V High Side Current Sense

\[ V_{OUT} = I_L \cdot \frac{R_2}{R_T} \cdot R_S - V_{GS} \cdot \frac{R_2}{R_T} \]

\[ 0V \leq V_{OUT} \leq V_{DD} - V_{GS, MOSFET} \]

Low Average Power IR LED Driver

VARYING ON DUTY CYCLE REDUCES AVERAGE POWER CONSUMPTION

Accelerometer Signal Conditioner

\[ V_{OUT} = 60mV/g \]

WHERE \( g \) = EARTH'S GRAVITATIONAL CONSTANT

Photodiode Amplifier

AT 870nm (IR),
\[ V_{OUT} = 600mW/\mu W \] RECEIVED POWER
6 Decade Current Log Amplifier

Humidity Sensor Signal Conditioner

A TO D: LTC6079
V_{OUT} = 150mV \cdot \log (I_{IN}) + 1.23V, I_{IN} IN AMPS

Q1, Q2: DIODES INC. DMMT3906W

H: GE PARAMETRICS G-CAP 2 HUMIDITY SENSOR
148pF TO 178pF, 0% TO 90% RH
M1: VN2222L
LTC6078/LTC6079

TYPICAL APPLICATIONS

LDO Load Balancing

BALLAST RESISTANCE: IDENTICAL LENGTH THERMALLY MATED WIRE OR PCB TRACE

VDD

IN OUT
LT1763
SRDN BYP
FB
R2
R1
2k
2k
0.1μF
0.1μF
100kΩ

LOAD

ILOAD

VOUT ≈ 1.22V \left(1 + \frac{R1}{R2}\right)

LOAD ILOAD

IN OUT
LT1763
SRDN BYP
FB
0.01μF
0.01μF
10μF
10μF

0 ≤ ILOAD ≤ 1.5A
1.22V ≤ VOUT ≤ VDD
LDO LOADS MATCH TO WITHIN 1mA WITH 10mΩ OF BALLAST RESISTANCE (2 INCHES OF AWG 28 GAUGE STRANDED WIRE)
A, B: LTC6078

pH Probe Amplifier

VOUT = 1.25V + 59.2mV • (pH – 7)
A, B: LTC6078

VCC

57.6k

LT1634
1.25V

ph

+3500ppm/°C

PH SENSOR: SENSOREX S200C pH PROBE
LTC6078 INPUT IMPEDANCE = 1TΩ OR GREATER
VOUT = 1.25V + 59.2mV • (pH – 7)
A, B: LTC6078

PRECISION RESISTOR PT146
1k

1k

1000pF
TYPICAL APPLICATIONS

Thermistor Amplifier with Overtemperature Alarm

A TO D: LTC6079, V<sub>DD</sub> = 2.7V TO 5.5V, V<sub>SS</sub> = GND
V<sub>OUT</sub> = 0 → 1V FOR 0°C TO 100°C, LINEAR
T<sub>OV</sub> → HIGH WHEN T ≥ 90°C

Precision Sample-and-Hold

I<sub>SUPPLY</sub> < 200μA
VOLTAGE DROOP = 130nV/ms TYP
SLEW RATE = 0.05V/ms TYP
ACQ TIME = 84μs TYP TO 0.1%
TYPICAL APPLICATIONS

Precision Voltage-Controlled Current Source

\[ I_{OUT} = \frac{V_{IN}}{R_{SET}} \]

\[ I_{ERROR} < 0.1\% \text{ AT } I_{OUT} = 1\mu\text{A} \]

60Hz Notch

\[ V_{OUT} = \left(1 + \frac{R_2}{R_1}\right) \cdot V_{IN} \]

\[ \text{NOTCH DEPTH} = -60\text{dB AT 60Hz, RTI} \]
PACKAGE DESCRIPTION

DD Package
10-Lead Plastic DFN (3mm x 3mm)
(Reference LTC DWG # 05-08-1699)

NOTE:
1. DRAWING TO BE MADE A JEDEC PACKAGE OUTLINE MO-229 VARIATION OF (WEED-2).
   CHECK THE LTC WEBSITE DATA SHEET FOR CURRENT STATUS OF VARIATION ASSIGNMENT
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE TOP AND BOTTOM OF PACKAGE
PACKAGE DESCRIPTION

DHC Package
16-Lead Plastic DFN (5mm × 3mm)
(Reference LTC DWG # 05-08-1706)

RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS

NOTE:
1. DRAWING PROPOSED TO BE MADE VARIATION OF VERSION (WJED-1) IN JEDEC
   PACKAGE OUTLINE MO-229
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE
   MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE
   TOP AND BOTTOM OF PACKAGE
MS8 Package
8-Lead Plastic MSOP
(Reference LTC DWG # 05-08-1660)

RECOMMENDED SOLDER PAD LAYOUT

DETAIL “A”

GAUGE PLANE

GAGE PLANE

DETAIL “A”

SEATING PLANE

GAGE PLANE

NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
2. DRAWING NOT TO SCALE
3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
   MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006”) PER SIDE
4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
   INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.152mm (.006”) PER SIDE
5. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.102mm (.004”) MAX
PACKAGE DESCRIPTION

GN Package
16-Lead Plastic SSOP (Narrow .150 Inch)
(Reference LTC DWG # 05-08-1641)

NOTE:
1. CONTROLLING DIMENSION: INCHES
2. DIMENSIONS ARE IN INCHES (MILLIMETERS)
3. DRAWING NOT TO SCALE
   *DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH
   SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE
   **DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD
   FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

RECOMMENDED SOLDER PAD LAYOUT
TYPICAL APPLICATION

DC Accurate Composite Amplifier, Gain of 1000

CIRCUIT BW = 1.25MHz
εn = 2.6nV/√Hz (RTI) AT 1kHz
CIRCUIT VOS = 25µV (MAX) RTI

RELATED PARTS

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTC2051/LTC2052</td>
<td>Dual/Quad Zero-Drift Op Amps</td>
<td>3µV VOS, 30nV/°C VOS Drift</td>
</tr>
<tr>
<td>LT6011/LT6012</td>
<td>Dual/Quad Precision Op Amps</td>
<td>60µV VOS, IB = 300pA, IS = 135µA</td>
</tr>
</tbody>
</table>