

1.5V, micro SMD, Dual-Gain Analog Temperature Sensor with Class AB Output

General Description

The LM20LV is a precision analog output CMOS integrated-circuit temperature sensor that operates at a supply voltage as low as 1.5 Volts. Available in the very small four-bump microSMD (0.8mm x 0.8mm) the LM20LV occupies very little board area. A class-AB output structure gives the LM20LV strong output source and sink current capability for driving heavy loads, making it well suited to source the input of a sample-and-hold analog-to-digital converter with its transient load requirements. This generally means the LM20LV can be used without external components, like resistors and buffers, on the output. While operating over the wide temperature range of -50°C to $+150^{\circ}\text{C}$, the LM20LV delivers an output voltage that is inversely proportional to measured temperature. The LM20LV's low supply current makes it ideal for battery-powered systems as well as general temperature sensing applications.

A Gain Select (GS) pin sets the gain of the temperature-to-voltage output transfer function. Either of two slopes are selectable: $-5.5\text{ mV}/^{\circ}\text{C}$ (GS=0) or $-8.2\text{ mV}/^{\circ}\text{C}$ (GS=1). In the lowest gain configuration, the LM20LV can operate with a 1.5V supply while measuring temperature over the full -50°C to $+150^{\circ}\text{C}$ operating range. Tying GS high causes the transfer function to have the largest gain for maximum temperature sensitivity. The gain-select inputs can be tied directly to V_{DD} or Ground without any pull-up or pull-down resistors, reducing component count and board area. These inputs can also be driven by logic signals allowing the system to optimize the gain during operation or system diagnostics.

Applications

- Cell phones
- Wireless Transceivers

- Battery Management
- Automotive
- Disk Drives
- Games
- Appliances

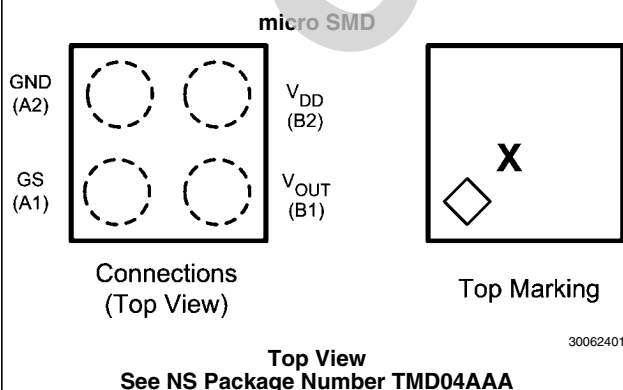
Features

- Low 1.5V operation
- Push-pull output with $50\mu\text{A}$ source current capability
- Two selectable gains
- Very accurate over wide temperature range of -50°C to $+150^{\circ}\text{C}$
- Low quiescent current
- Output is short-circuit protected
- Extremely small microSMD package
- Footprint compatible with the industry-standard LM20 temperature sensor

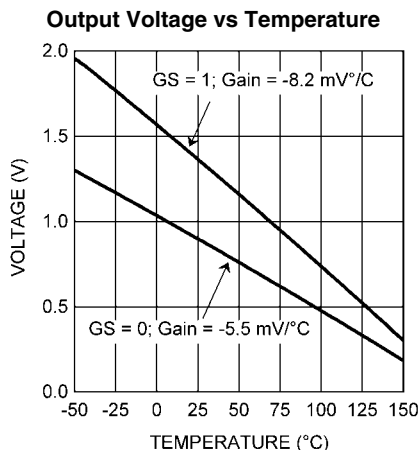
Key Specifications

| | |
|-------------------------|--|
| ■ Supply Voltage | 1.5V to 5.5V |
| ■ Supply Current | 5.4 μA (typ) |
| ■ Output Drive | $\pm 50\text{ }\mu\text{A}$ |
| ■ Temperature Accuracy | 20°C to 40°C $\pm 1.5^{\circ}\text{C}$ -50°C to 70°C $\pm 1.8^{\circ}\text{C}$ -50°C to 90°C $\pm 2.1^{\circ}\text{C}$ -50°C to 150°C $\pm 2.7^{\circ}\text{C}$ |
| ■ Operating Temperature | -50°C to 150°C |

Connection Diagram

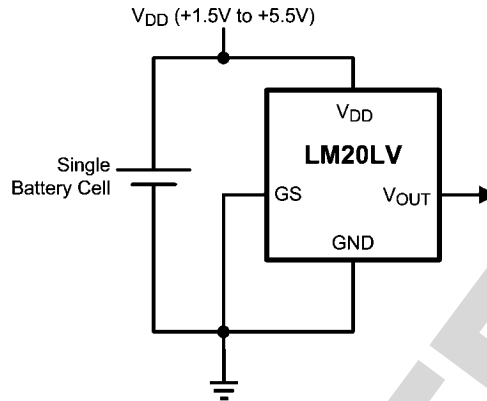


Typical Transfer Characteristic



Typical Application

Full-Range Celsius Temperature Sensor (-50°C to $+150^{\circ}\text{C}$)
Operating from a Single Battery Cell



30062402

Ordering Information

| Order Number | Temperature Accuracy | NS Package Number | Device Marking | Transport Media |
|--------------|--|-------------------|----------------|-----------------------------|
| LM20LVTME | $\pm 1.5^{\circ}\text{C}$ to $\pm 2.7^{\circ}\text{C}$ | TMD04AAA | Date Code | 250 Units on Tape and Reel |
| LM20LVTMX | $\pm 1.5^{\circ}\text{C}$ to $\pm 2.7^{\circ}\text{C}$ | TMD04AAA | Date Code | 3000 Units on Tape and Reel |

Pin Descriptions

| Label | Pin Number | Type | Equivalent Circuit | Function |
|------------------|------------|---------------|--------------------|---|
| GS | A1 | Logic Input | | Gain Select - Input for selecting the slope of the analog output response |
| GND | A2 | Ground | | Power Supply Ground |
| V _{OUT} | B1 | Analog Output | | Outputs a voltage which is inversely proportional to temperature |
| V _{DD} | B2 | Power | | Positive Supply Voltage |

Absolute Maximum Ratings (Note 1)

| | |
|---|------------------------------|
| Supply Voltage | −0.3V to +6.0V |
| Voltage at Output Pin | −0.3V to ($V_{DD} + 0.3V$) |
| Output Current | ±7 mA |
| Voltage at GS Input Pin | −0.3V to +6.0V |
| Input Current at any pin (Note 2) | 5 mA |
| Storage Temperature | −65°C to +150°C |
| Maximum Junction Temperature (T_{JMAX}) | +150°C |
| ESD Susceptibility (Note 3): | |
| Human Body Model | 2500V |
| Machine Model | 250V |

Soldering process must comply with National's
Reflow Temperature Profile specifications. Refer to
www.national.com/packaging. (Note 4)

Operating Ratings (Note 1)

| | |
|--------------------------------------|---------------------------------|
| Specified Temperature Range: | $T_{MIN} \leq T_A \leq T_{MAX}$ |
| LM20LV | −50°C ≤ T_A ≤ +150°C |
| Supply Voltage Range (V_{DD}) | +1.5 V to +5.5 V |
| Thermal Resistance (θ_{JA}) | |
| LM20LVTME, LM20LVTMX | 122.6°C/W |

Accuracy Characteristics

These limits do not include DC load regulation. These stated accuracy limits are with reference to the values in the LM20LV Transfer Table.

| Parameter | Conditions | | Limits (Note 7) | Units (Limit) |
|-------------------------------|------------|---|--------------------|------------------|
| Temperature Error (Note 8) | GS=0 | $T_A = +20^\circ\text{C to } +40^\circ\text{C}; V_{DD} = 1.5V \text{ to } 5.5V$ | ±1.5 | °C (max) |
| | | $T_A = +0^\circ\text{C to } +70^\circ\text{C}; V_{DD} = 1.5V \text{ to } 5.5V$ | ±1.8 | °C (max) |
| | | $T_A = +0^\circ\text{C to } +90^\circ\text{C}; V_{DD} = 1.5V \text{ to } 5.5V$ | ±2.1 | °C (max) |
| | | $T_A = +0^\circ\text{C to } +120^\circ\text{C}; V_{DD} = 1.5V \text{ to } 5.5V$ | ±2.4 | °C (max) |
| | | $T_A = +0^\circ\text{C to } +150^\circ\text{C}; V_{DD} = 1.5V \text{ to } 5.5V$ | ±2.7 | °C (max) |
| | | $T_A = -50^\circ\text{C to } +0^\circ\text{C}; V_{DD} = 1.6V \text{ to } 5.5V$ | ±1.8 | °C (max) |
| | GS=1 | $T_A = +20^\circ\text{C to } +40^\circ\text{C}; V_{DD} = 1.8V \text{ to } 5.5V$ | ±1.5 | °C (max) |
| | | $T_A = +0^\circ\text{C to } +70^\circ\text{C}; V_{DD} = 1.9V \text{ to } 5.5V$ | ±1.8 | °C (max) |
| | | $T_A = +0^\circ\text{C to } +90^\circ\text{C}; V_{DD} = 1.9V \text{ to } 5.5V$ | ±2.1 | °C (max) |
| | | $T_A = +0^\circ\text{C to } +120^\circ\text{C}; V_{DD} = 1.9V \text{ to } 5.5V$ | ±2.4 | °C (max) |
| | | $T_A = +0^\circ\text{C to } +150^\circ\text{C}; V_{DD} = 1.9V \text{ to } 5.5V$ | ±2.7 | °C (max) |
| | | $T_A = -50^\circ\text{C to } +0^\circ\text{C}; V_{DD} = 2.3V \text{ to } 5.5V$ | ±1.8 | °C (max) |

Electrical Characteristics

Unless otherwise noted, these specifications apply for $+V_{DD} = +1.5V$ to $+5.5V$. **Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}** ; all other limits $T_A = T_J = 25^\circ C$.

| Symbol | Parameter | Conditions | Typical (Note 6) | Limits (Note 7) | Units (Limit) |
|----------|--|--|---------------------|-----------------------------------|------------------|
| | Sensor Gain | GS = 0 | -5.5 | | mV/°C |
| | | GS = 1 | -8.2 | | mV/°C |
| | Load Regulation (Note 10) | 1.5V $\leq V_{DD} < 5.5V$ Source $\leq 50 \mu A$, ($V_{DD} - V_{OUT}$) $\geq 200mV$ | -0.22 | -1 | mV (max) |
| | | Sink $\leq 50 \mu A$, $V_{OUT} \geq 200mV$ | 0.26 | 1 | mV (max) |
| | Line Regulation (Note 13) | | 200 | | $\mu V/V$ |
| I_S | Supply Current | $T_A = +30^\circ C$ to $+150^\circ C$, ($V_{DD} - V_{OUT}$) $\geq 100mV$ | 5.4 | 8.1 | μA (max) |
| | | $T_A = -50^\circ C$ to $+150^\circ C$, ($V_{DD} - V_{OUT}$) $\geq 100mV$ | 5.4 | 9 | μA (max) |
| C_L | Output Load Capacitance | | 1100 | | pF (max) |
| | Power-on Time (Note 11) | $C_L = 0$ pF to 1100 pF | 0.7 | 1.9 | ms (max) |
| V_{IH} | GS1 and GS0 Input Logic "1" Threshold Voltage | | | $V_{DD} - 0.5V$ | V (min) |
| V_{IL} | GS1 and GS0 Input Logic "0" Threshold Voltage | | | 0.5 | V (max) |
| I_{IH} | Logic "1" Input Current (Note 12) | | 0.001 | 1 | μA (max) |
| I_{IL} | Logic "0" Input Current (Note 12) | | 0.001 | 1 | μA (max) |

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 2: When the input voltage (V_I) at any pin exceeds power supplies ($V_I < GND$ or $V_I > V^+$), the current at that pin should be limited to 5 mA.

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5 k Ω resistor into each pin. The machine model is a 200 pF capacitor discharged directly into each pin.

Note 4: Reflow temperature profiles are different for lead-free and non-lead-free packages.

Note 5: The junction to ambient thermal resistance (θ_{JA}) is specified without a heat sink in still air.

Note 6: Typicals are at $T_J = T_A = 25^\circ C$ and represent most likely parametric norm.

Note 7: Limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

Note 8: Accuracy is defined as the error between the measured and reference output voltages, tabulated in the Transfer Table at the specified conditions of supply gain setting, voltage, and temperature (expressed in $^\circ C$). Accuracy limits include line regulation within the specified conditions. Accuracy limits do not include load regulation; they assume no DC load.

Note 9: Changes in output due to self heating can be computed by multiplying the internal dissipation by the thermal resistance.

Note 10: Source currents are flowing out of the LM20LV. Sink currents are flowing into the LM20LV.

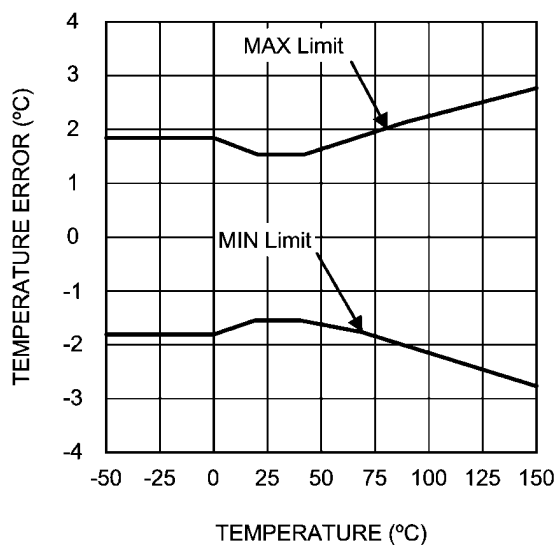
Note 11: Guaranteed by design.

Note 12: The input current is leakage only and is highest at high temperature. It is typically only 0.001 μA . The 1 μA limit is solely based on a testing limitation and does not reflect the actual performance of the part.

Note 13: Line regulation (DC) is calculated by subtracting the output voltage at the highest supply voltage from the output voltage at the lowest supply voltage. The typical DC line regulation specification does not include the output voltage shift discussed in Section 5.0.

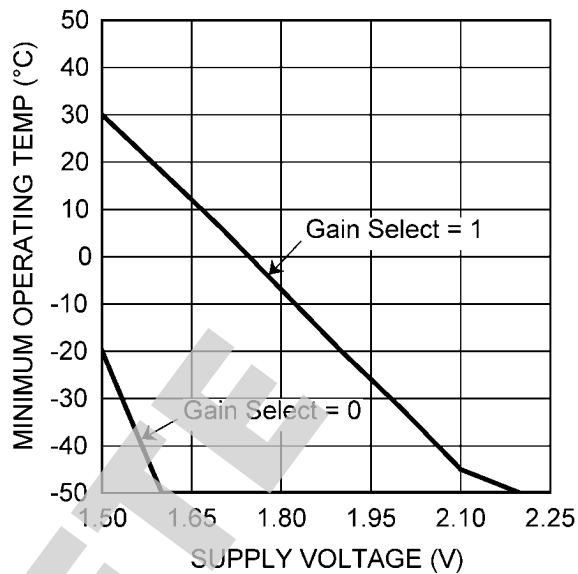
Typical Performance Characteristics

Temperature Error vs. Temperature



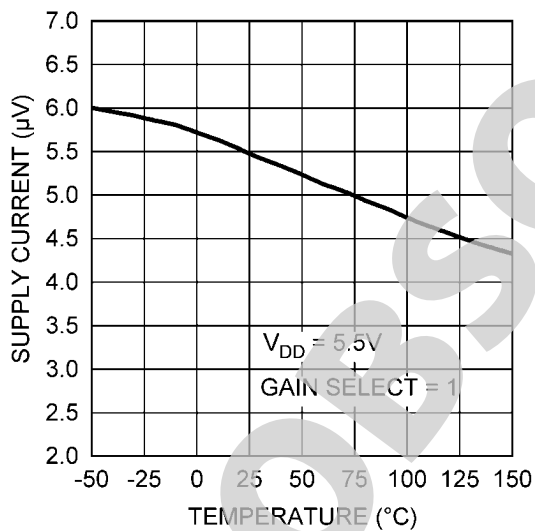
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Minimum Operating Temperature vs. Supply Voltage



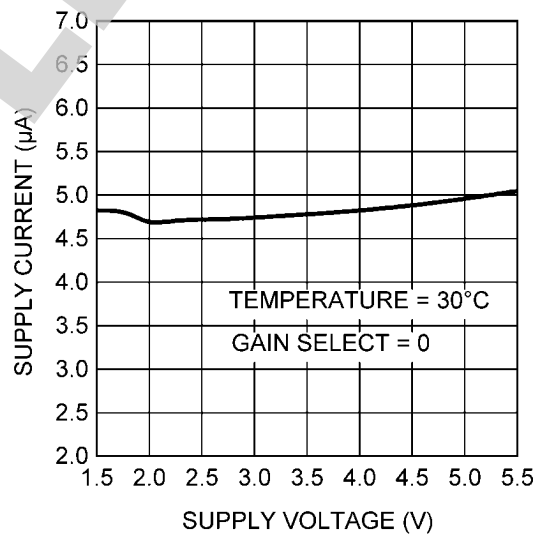
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Supply Current vs. Temperature



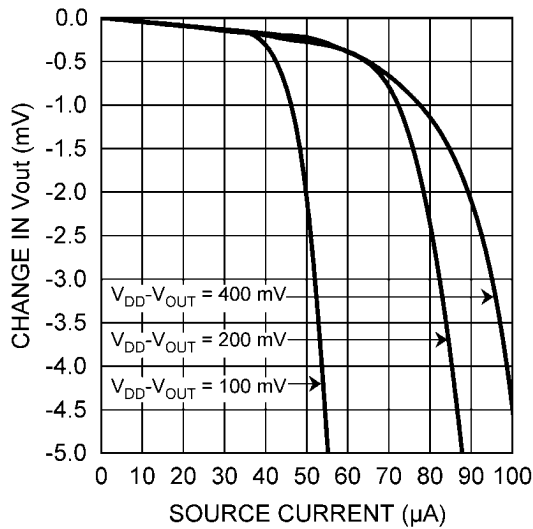
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Supply Current vs. Supply Voltage

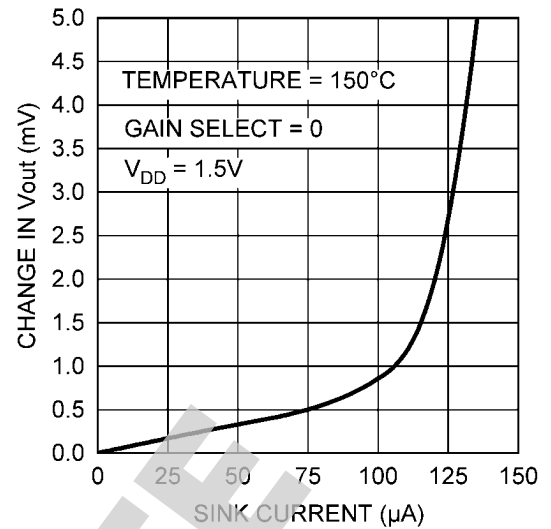


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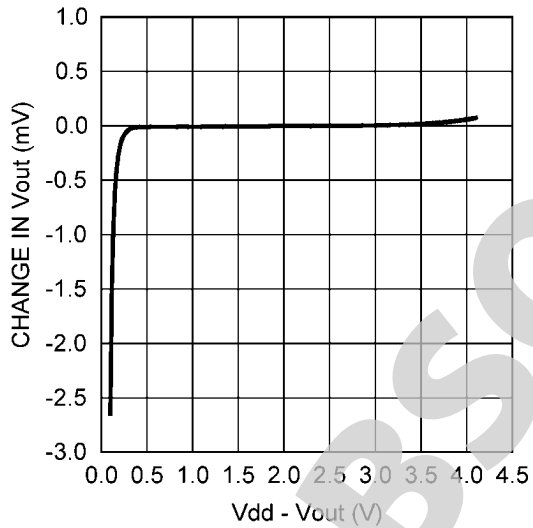
Load Regulation, Sourcing Current



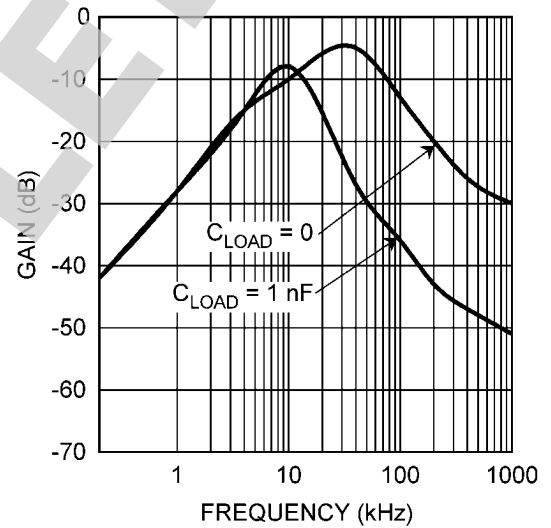
Load Regulation, Sinking Current



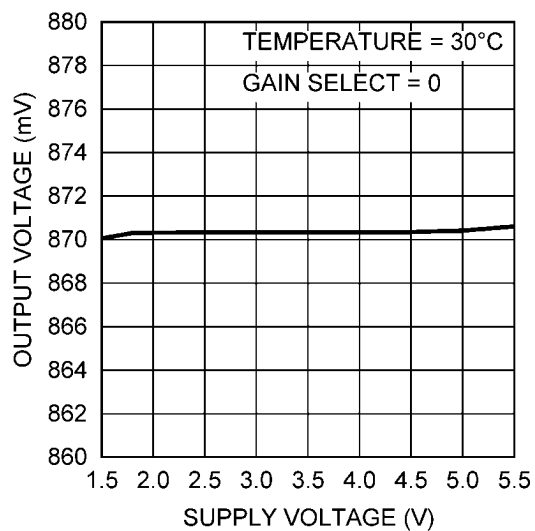
Line Regulation: Change in Vout vs. Overhead Voltage



Supply-Noise Gain vs. Frequency

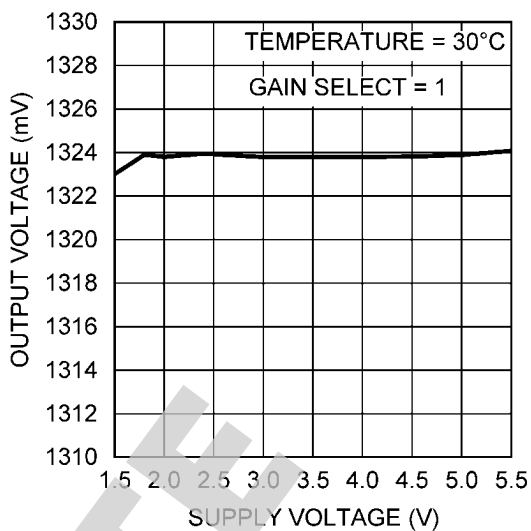


Line Regulation: Output Voltage vs. Supply Voltage
Gain Select = 0



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Line Regulation: Output Voltage vs. Supply Voltage
Gain Select = 1



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1.0 LM20LV Transfer Function

The LM20LV has two selectable gains, selected by the Gain Select (GS) input pin. The output voltage for each gain, across the complete operating temperature range is shown in the LM20LV Transfer Table, below. This table is the reference from which the LM20LV accuracy specifications (listed in the Electrical Characteristics section) are determined. This table can be used, for example, in a host processor look-up table. A file containing this data is available for download at www.national.com/appinfo/tempsensors.

LM20LV Temperature-Voltage Transfer Table

The output voltages in this table apply for $V_{DD} = 5V$.

| Temperature (°C) | GS = 0 (mV) | GS = 1 (mV) |
|------------------|-------------|-------------|
| -50 | 1299 | 1955 |
| -49 | 1294 | 1949 |
| -48 | 1289 | 1942 |
| -47 | 1284 | 1935 |
| -46 | 1278 | 1928 |
| -45 | 1273 | 1921 |
| -44 | 1268 | 1915 |
| -43 | 1263 | 1908 |
| -42 | 1257 | 1900 |
| -41 | 1252 | 1892 |
| -40 | 1247 | 1885 |
| -39 | 1242 | 1877 |
| -38 | 1236 | 1869 |
| -37 | 1231 | 1861 |
| -36 | 1226 | 1853 |
| -35 | 1221 | 1845 |
| -34 | 1215 | 1838 |
| -33 | 1210 | 1830 |
| -32 | 1205 | 1822 |
| -31 | 1200 | 1814 |
| -30 | 1194 | 1806 |
| -29 | 1189 | 1798 |
| -28 | 1184 | 1790 |
| -27 | 1178 | 1783 |
| -26 | 1173 | 1775 |
| -25 | 1168 | 1767 |
| -24 | 1162 | 1759 |
| -23 | 1157 | 1751 |
| -22 | 1152 | 1743 |
| -21 | 1146 | 1735 |
| -20 | 1141 | 1727 |
| -19 | 1136 | 1719 |
| -18 | 1130 | 1711 |
| -17 | 1125 | 1703 |
| -16 | 1120 | 1695 |
| -15 | 1114 | 1687 |
| -14 | 1109 | 1679 |

| Temperature (°C) | GS = 0 (mV) | GS = 1 (mV) |
|------------------|-------------|-------------|
| -13 | 1104 | 1671 |
| -12 | 1098 | 1663 |
| -11 | 1093 | 1656 |
| -10 | 1088 | 1648 |
| -9 | 1082 | 1639 |
| -8 | 1077 | 1631 |
| -7 | 1072 | 1623 |
| -6 | 1066 | 1615 |
| -5 | 1061 | 1607 |
| -4 | 1055 | 1599 |
| -3 | 1050 | 1591 |
| -2 | 1044 | 1583 |
| -1 | 1039 | 1575 |
| 0 | 1034 | 1567 |
| 1 | 1028 | 1559 |
| 2 | 1023 | 1551 |
| 3 | 1017 | 1543 |
| 4 | 1012 | 1535 |
| 5 | 1007 | 1527 |
| 6 | 1001 | 1519 |
| 7 | 996 | 1511 |
| 8 | 990 | 1502 |
| 9 | 985 | 1494 |
| 10 | 980 | 1486 |
| 11 | 974 | 1478 |
| 12 | 969 | 1470 |
| 13 | 963 | 1462 |
| 14 | 958 | 1454 |
| 15 | 952 | 1446 |
| 16 | 947 | 1438 |
| 17 | 941 | 1430 |
| 18 | 936 | 1421 |
| 19 | 931 | 1413 |
| 20 | 925 | 1405 |
| 21 | 920 | 1397 |
| 22 | 914 | 1389 |
| 23 | 909 | 1381 |
| 24 | 903 | 1373 |
| 25 | 898 | 1365 |
| 26 | 892 | 1356 |
| 27 | 887 | 1348 |
| 28 | 882 | 1340 |
| 29 | 876 | 1332 |
| 30 | 871 | 1324 |
| 31 | 865 | 1316 |
| 32 | 860 | 1308 |
| 33 | 854 | 1299 |
| 34 | 849 | 1291 |
| 35 | 843 | 1283 |

| Temperature (°C) | GS = 0 (mV) | GS = 1 (mV) |
|---------------------|----------------|----------------|
| 36 | 838 | 1275 |
| 37 | 832 | 1267 |
| 38 | 827 | 1258 |
| 39 | 821 | 1250 |
| 40 | 816 | 1242 |
| 41 | 810 | 1234 |
| 42 | 804 | 1225 |
| 43 | 799 | 1217 |
| 44 | 793 | 1209 |
| 45 | 788 | 1201 |
| 46 | 782 | 1192 |
| 47 | 777 | 1184 |
| 48 | 771 | 1176 |
| 49 | 766 | 1167 |
| 50 | 760 | 1159 |
| 51 | 754 | 1151 |
| 52 | 749 | 1143 |
| 53 | 743 | 1134 |
| 54 | 738 | 1126 |
| 55 | 732 | 1118 |
| 56 | 726 | 1109 |
| 57 | 721 | 1101 |
| 58 | 715 | 1093 |
| 59 | 710 | 1084 |
| 60 | 704 | 1076 |
| 61 | 698 | 1067 |
| 62 | 693 | 1059 |
| 63 | 687 | 1051 |
| 64 | 681 | 1042 |
| 65 | 676 | 1034 |
| 66 | 670 | 1025 |
| 67 | 664 | 1017 |
| 68 | 659 | 1008 |
| 69 | 653 | 1000 |
| 70 | 647 | 991 |
| 71 | 642 | 983 |
| 72 | 636 | 974 |
| 73 | 630 | 966 |
| 74 | 625 | 957 |
| 75 | 619 | 949 |
| 76 | 613 | 941 |
| 77 | 608 | 932 |
| 78 | 602 | 924 |
| 79 | 596 | 915 |
| 80 | 591 | 907 |
| 81 | 585 | 898 |
| 82 | 579 | 890 |
| 83 | 574 | 881 |
| 84 | 568 | 873 |

| Temperature (°C) | GS = 0 (mV) | GS = 1 (mV) |
|---------------------|----------------|----------------|
| 85 | 562 | 865 |
| 86 | 557 | 856 |
| 87 | 551 | 848 |
| 88 | 545 | 839 |
| 89 | 539 | 831 |
| 90 | 534 | 822 |
| 91 | 528 | 814 |
| 92 | 522 | 805 |
| 93 | 517 | 797 |
| 94 | 511 | 788 |
| 95 | 505 | 779 |
| 96 | 499 | 771 |
| 97 | 494 | 762 |
| 98 | 488 | 754 |
| 99 | 482 | 745 |
| 100 | 476 | 737 |
| 101 | 471 | 728 |
| 102 | 465 | 720 |
| 103 | 459 | 711 |
| 104 | 453 | 702 |
| 105 | 448 | 694 |
| 106 | 442 | 685 |
| 107 | 436 | 677 |
| 108 | 430 | 668 |
| 109 | 425 | 660 |
| 110 | 419 | 651 |
| 111 | 413 | 642 |
| 112 | 407 | 634 |
| 113 | 401 | 625 |
| 114 | 396 | 617 |
| 115 | 390 | 608 |
| 116 | 384 | 599 |
| 117 | 378 | 591 |
| 118 | 372 | 582 |
| 119 | 367 | 573 |
| 120 | 361 | 565 |
| 121 | 355 | 556 |
| 122 | 349 | 547 |
| 123 | 343 | 539 |
| 124 | 337 | 530 |
| 125 | 332 | 521 |
| 126 | 326 | 513 |
| 127 | 320 | 504 |
| 128 | 314 | 495 |
| 129 | 308 | 487 |
| 130 | 302 | 478 |
| 131 | 296 | 469 |
| 132 | 291 | 460 |
| 133 | 285 | 452 |

| Temperature (°C) | GS = 0 (mV) | GS = 1 (mV) |
|---------------------|----------------|----------------|
| 134 | 279 | 443 |
| 135 | 273 | 434 |
| 136 | 267 | 425 |
| 137 | 261 | 416 |
| 138 | 255 | 408 |
| 139 | 249 | 399 |
| 140 | 243 | 390 |
| 141 | 237 | 381 |
| 142 | 231 | 372 |
| 143 | 225 | 363 |
| 144 | 219 | 354 |
| 145 | 213 | 346 |
| 146 | 207 | 337 |
| 147 | 201 | 328 |
| 148 | 195 | 319 |
| 149 | 189 | 310 |
| 150 | 183 | 301 |

Although the LM20LV is very linear, its response does have a slight downward parabolic shape. This shape is very accurately reflected in the LM20LV Transfer Table. For a linear approximation, a line can easily be calculated over the de-

sired temperature range from the Table using the two-point equation:

$$V - V_1 = \left(\frac{V_2 - V_1}{T_2 - T_1} \right) \times (T - T_1)$$

Where V is in mV, T is in °C, T₁ and V₁ are the coordinates of the lowest temperature, T₂ and V₂ are the coordinates of the highest temperature.

For example, if we want to determine the equation of a line with the Gain Setting at GS1 = 0 and GS0 = 0, over a temperature range of 20°C to 50°C, we would proceed as follows:

$$V - 925 \text{ mV} = \left(\frac{760 \text{ mV} - 925 \text{ mV}}{50^\circ\text{C} - 20^\circ\text{C}} \right) \times (T - 20^\circ\text{C})$$

$$V - 925 \text{ mV} = (-5.50 \text{ mV} / ^\circ\text{C}) \times (T - 20^\circ\text{C})$$

$$V = (-5.50 \text{ mV} / ^\circ\text{C}) \times T + 1035 \text{ mV}$$

Using this method of linear approximation, the transfer function can be approximated for one or more temperature ranges of interest.

2.0 Mounting and Thermal Conductivity

The LM20LV can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface.

To ensure good thermal conductivity, the backside of the LM20LV die is directly attached to the GND pin (Pin 2). The temperatures of the lands and traces to the other leads of the LM20LV will also affect the temperature reading.

Alternatively, the LM20LV can be mounted inside a sealed-end metal tube, and can then be dipped into a bath or screwed into a threaded hole in a tank. As with any IC, the LM20LV and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit may operate at cold temperatures where condensation can occur. If moisture creates a short circuit from the output to ground or V_{DD} , the output from the LM20LV will not be correct. Printed-circuit coatings are often used to ensure that moisture cannot corrode the leads or circuit traces. The thermal resistance junction to ambient (θ_{JA}) is the parameter used to calculate the rise of a device junction temperature due to its power dissipation. The equation used to calculate the rise in the LM20LV's die temperature is

$$T_J = T_A + \theta_{JA} [(V_{DD} I_Q) + (V_{DD} - V_O) I_L]$$

where T_A is the ambient temperature, I_Q is the quiescent current, I_L is the load current on the output, and V_O is the output voltage. For example, in an application where $T_A = 30^\circ\text{C}$, $V_{DD} = 5\text{ V}$, $I_{DD} = 9\text{ }\mu\text{A}$, Gain Select = 11, $V_{OUT} = 2.231\text{ mV}$, and $I_L = 2\text{ }\mu\text{A}$, the junction temperature would be 30.021°C , showing a self-heating error of only 0.021°C . Since the LM20LV's junction temperature is the actual temperature being measured, care should be taken to minimize the load current that the LM20LV is required to drive. Figure 1 shows the thermal resistance of the LM20LV.

| Device Number | NS Package Number | Thermal Resistance (θ_{JA}) |
|-------------------------|-------------------|--------------------------------------|
| LM20LVTME, LM20LVTMX | TMD04AAA | 122.6 $^\circ\text{C/W}$ |

FIGURE 1. LM20LV Thermal Resistance

3.0 Output and Noise Considerations

A push-pull output gives the LM20LV the ability to sink and source significant current. This is beneficial when, for example, driving dynamic loads like an input stage on an analog-to-digital converter (ADC). In these applications the source current is required to quickly charge the input capacitor of the ADC. See the Applications Circuits section for more discussion of this topic. The LM20LV is ideal for this and other applications which require strong source or sink current.

The LM20LV's supply-noise gain (the ratio of the AC signal on V_{OUT} to the AC signal on V_{DD}) was measured during bench tests. It's typical attenuation is shown in the Typical Performance Characteristics section. A load capacitor on the output can help to filter noise.

For operation in very noisy environments, some bypass capacitance should be present on the supply within approximately 2 inches of the LM20LV.

4.0 Capacitive Loads

The LM20LV handles capacitive loading well. In an extremely noisy environment, or when driving a switched sampling input on an ADC, it may be necessary to add some filtering to minimize noise coupling. Without any precautions, the LM20LV can drive a capacitive load less than or equal to 1100 pF as shown in Figure 2. For capacitive loads greater than 1100 pF , a series resistor may be required on the output, as shown in Figure 3.

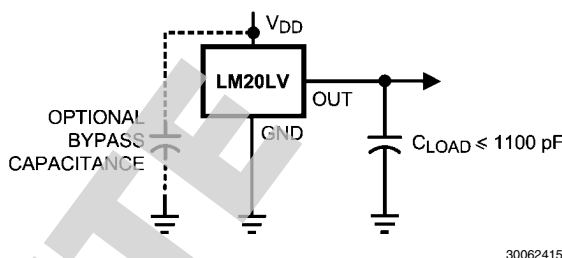
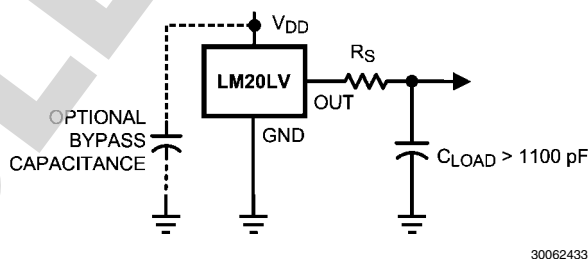


FIGURE 2. LM20LV No Decoupling Required for Capacitive Loads Less than 1100 pF .



| C_{LOAD} | Minimum R_S |
|------------------|----------------|
| 1.1 nF to 99 nF | 3 k Ω |
| 100 nF to 999 nF | 1.5 k Ω |
| 1 μF | 800 Ω |

FIGURE 3. LM20LV with series resistor for capacitive loading greater than 1100 pF .

5.0 Output Voltage Shift

The LM20LV is very linear over temperature and supply voltage range. Due to the intrinsic behavior of an NMOS/PMOS rail-to-rail buffer, a slight shift in the output can occur when the supply voltage is ramped over the operating range of the device. The location of the shift is determined by the relative levels of V_{DD} and V_{OUT} . The shift typically occurs when $V_{DD} - V_{OUT} = 1.0\text{ V}$.

This slight shift (a few millivolts) takes place over a wide change (approximately 200 mV) in V_{DD} or V_{OUT} . Since the shift takes place over a wide temperature change of 5°C to 20°C , V_{OUT} is always monotonic. The accuracy specifications in the Electrical Characteristics table already include this possible shift.

6.0 Selectable Gain for Optimization and In Situ Testing

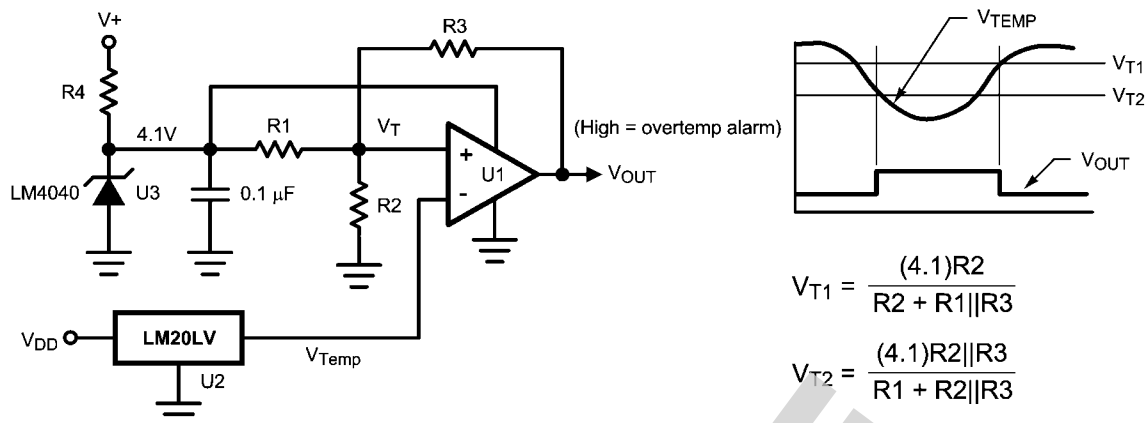
The Gain Select digital inputs can be tied to the rails or can be driven from digital outputs such as microcontroller GPIO pins. In low-supply voltage applications, the ability to reduce the gain to $-5.5 \text{ mV}/^\circ\text{C}$ allows the LM20LV to operate over the full -50°C to 150°C range. When a larger supply voltage is present, the gain can be increased as high as $-8.2 \text{ mV}/^\circ\text{C}$. The larger gain is optimal for reducing the effects of noise (for ex-

ample, noise coupling on the output line or quantization noise induced by an analog-to-digital converter which may be sampling the LM20LV output).

Another application advantage of the digitally selectable gain is the ability to perform dynamic testing of the LM20LV while it is running in a system. By toggling the logic levels of the gain select pin and monitoring the resultant change in the output voltage level, the host system can verify the functionality of the LM20LV.

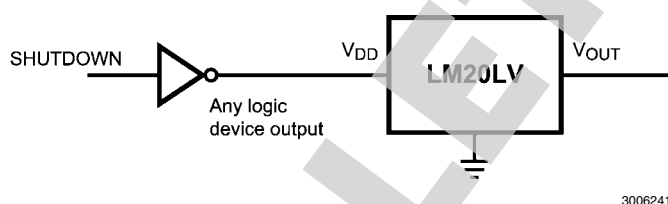
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7.0 Applications Circuits



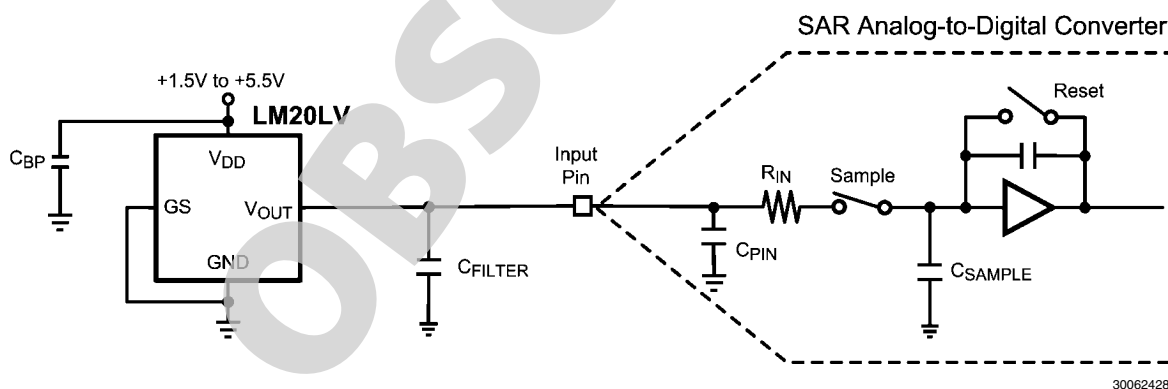
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FIGURE 4. Celsius Thermostat



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FIGURE 5. Conserving Power Dissipation with Shutdown

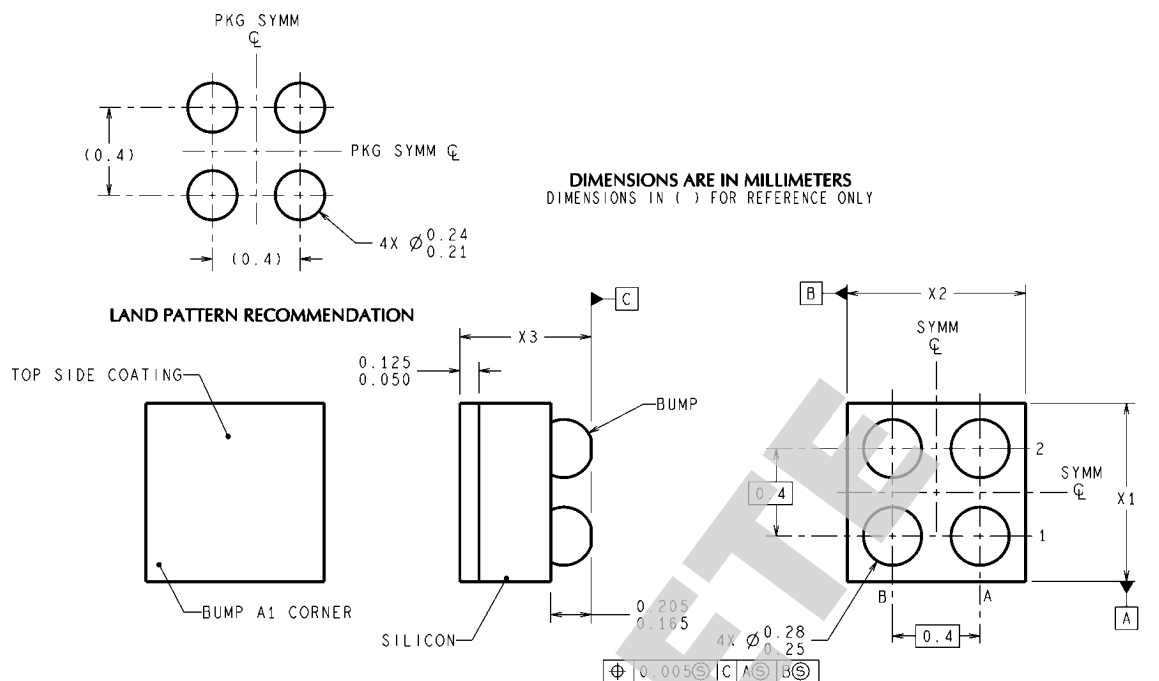


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Most CMOS ADCs found in microcontrollers and ASICs have a sampled data comparator input structure. When the ADC charges the sampling cap, it requires instantaneous charge from the output of the analog source such as the LM20LV temperature sensor and many op amps. This requirement is easily accommodated by the addition of a capacitor (C_{FILTER}). The size of C_{FILTER} depends on the size of the sampling capacitor and the sampling frequency. Since not all ADCs have identical input stages, the charge requirements will vary. This general ADC application is shown as an example only.

FIGURE 6. Suggested Connection to a Sampling Analog-to-Digital Converter Input Stage

Physical Dimensions inches (millimeters) unless otherwise noted



4-Bump Thin micro SMD Ball Grid Array Package
Order Number LM20LVTME, LM20LVTMX,
NS Package Number TMD04AAA

X1 = 0.815 mm

X2 = 0.815mm

X3 = 0.600mm

TMD04XXX (Rev A)

Notes

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Notes

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