

# MAX6613

## Low-Voltage Analog Temperature Sensor in an SC70 Package

### General Description

The MAX6613 is a low-power precision analog output temperature sensor in a tiny 5-pin SC70 package. The MAX6613 operates over a 1.8V to 5.5V supply voltage range, with a typical current consumption of only 7.5 $\mu$ A. It is particularly well suited for portable applications where minimizing battery cost and maximizing useful battery life are crucial.

The MAX6613 provides an analog voltage output proportional to temperature. Accuracy is  $\pm 4.0^{\circ}\text{C}$  (max) over a range of  $T_A = 0^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$  and  $\pm 4.4^{\circ}\text{C}$  (max) from  $T_A = -20^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$ . Self-heating effects are negligible due to the low current consumption of the part.

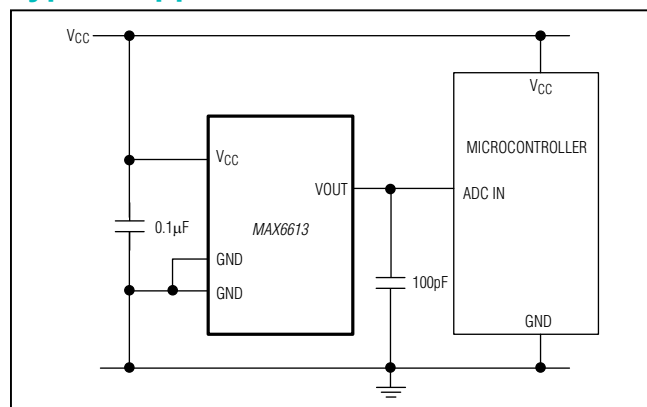
Unlike many analog temperature sensors, the MAX6613 is stable with any capacitive load from 0pF to 1000pF, providing broad flexibility in board-level design.

The operating temperature range varies with the voltage supply. The MAX6613 can be used over a  $-55^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$  range with a 2.5V to 5.5V supply voltage. For applications with a supply voltage of 1.8V, the MAX6613 can be used over a  $+25^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$  temperature range.

### Applications

- Cellular Phones
- GPS Equipment
- Medical Instruments
- Battery Management
- Appliances
- Disk Drives
- Printers
- Fax Machines
- HVAC

### Typical Application Circuit



### Benefits and Features

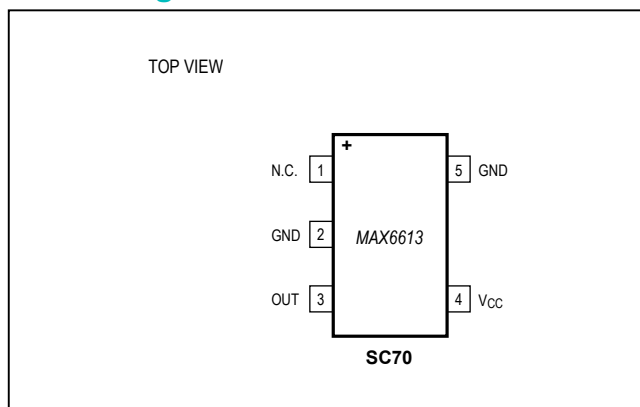
- Minimizes Power Consumption with Ultra-Low 7.5 $\mu$ A (typ) Supply Current
- Minimizes Board Space with Tiny SC70 Package
- Extends Performance Range with Wide 1.8V to 5.5V Operating Range
- Ideal for Broad Range of Thermal Management Applications
  - $-55^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$  Measurement Range
  - $4.0^{\circ}\text{C}$  Accuracy
- Pin Compatible with LM20

### Ordering Information

| PART           | TEMP RANGE                                      | PIN-PACKAGE | TOP MARK |
|----------------|-------------------------------------------------|-------------|----------|
| MAX6613MXK+T   | $-55^{\circ}\text{C}$ to $+130^{\circ}\text{C}$ | 5 SC70      | ADJ      |
| MAX6613MXK/V+T | $-55^{\circ}\text{C}$ to $+130^{\circ}\text{C}$ | 5 SC70      | ADJ      |

+Denotes a lead(Pb)-free/RoHS-compliant package.  
/V denotes an automotive qualified part.

### Pin Configuration



**Absolute Maximum Ratings**

(All voltages referenced to GND, unless otherwise noted.)

$V_{CC}$  to GND ..... -0.3V to +6V  
 All Other Pins to GND ..... -0.3V to ( $V_{CC}$  + 0.3V)  
 OUT Short to GND ..... Continuous  
 Output Current ..... -1mA to +50mA  
 ESD Protection (Human Body Model) ..... 2000V

Continuous Power Dissipation ( $T_A = +70^{\circ}\text{C}$ )

5-Pin SC70 (derate 3.1mW/ $^{\circ}\text{C}$  above  $+70^{\circ}\text{C}$ ) ..... 246.9mW  
 Operating Temperature Range .....  $-55^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$   
 Junction Temperature .....  $+150^{\circ}\text{C}$   
 Storage Temperature Range .....  $-65^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$   
 Lead Temperature (soldering 10s) .....  $+300^{\circ}\text{C}$   
 Soldering Temperature (reflow) .....  $+260^{\circ}\text{C}$

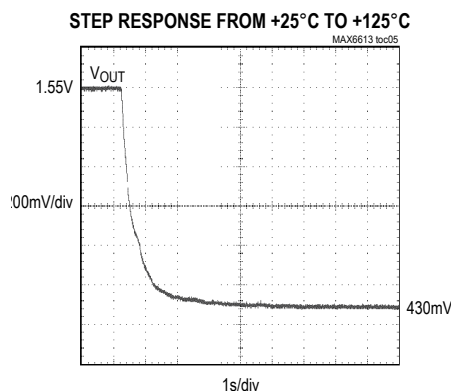
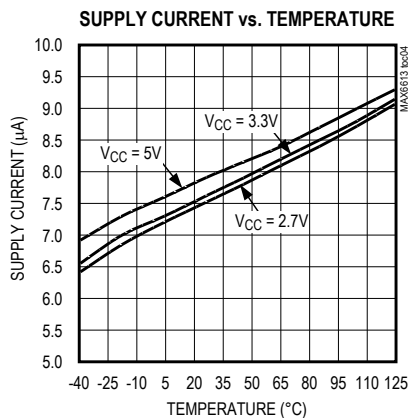
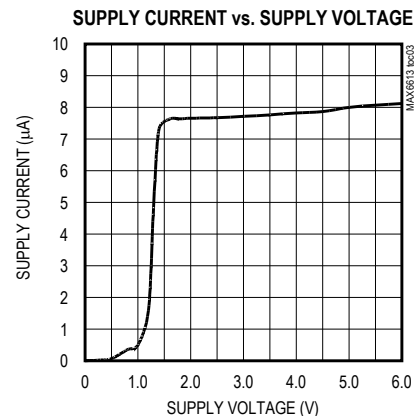
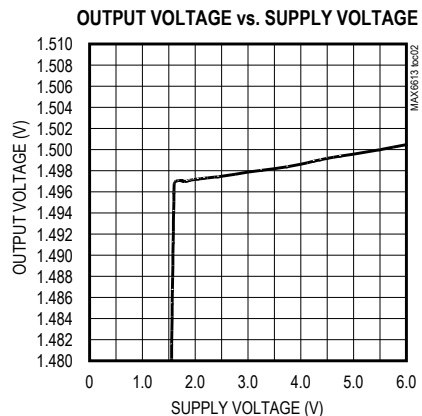
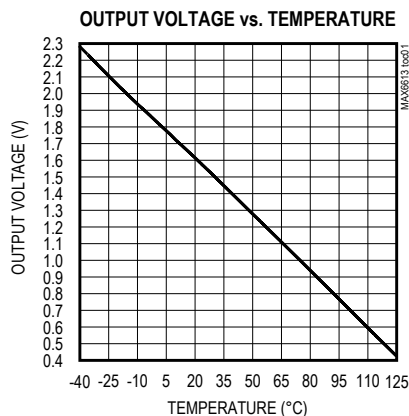
Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**DC Electrical Characteristics**(
 $V_{CC} = 1.8\text{V}$  to  $5.5\text{V}$ ,  $T_A = -55^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$ . Typical values are at  $T_A = +25^{\circ}\text{C}$ , unless otherwise noted.) (Note 1)

| PARAMETER                                              | SYMBOL | CONDITIONS                                                                         | MIN    | TYP       | MAX    | UNITS                  |
|--------------------------------------------------------|--------|------------------------------------------------------------------------------------|--------|-----------|--------|------------------------|
| Temperature-to-Voltage Error<br>(Notes 2, 3)           |        | $V_{CC} = 2.7\text{V}$ , $T_A = 0^{\circ}\text{C}$ to $+50^{\circ}\text{C}$        | -4     |           | +4     | $^{\circ}\text{C}$     |
|                                                        |        | $V_{CC} = 2.7\text{V}$ , $T_A = -20^{\circ}\text{C}$ to $+85^{\circ}\text{C}$      | -4.4   |           | +4.4   |                        |
|                                                        |        | $V_{CC} = 2.7\text{V}$ , $T_A = -55^{\circ}\text{C}$ to $+100^{\circ}\text{C}$     | -4.5   |           | +4.5   |                        |
|                                                        |        | $V_{CC} = 2.7\text{V}$ , $T_A = +100^{\circ}\text{C}$ to $+125^{\circ}\text{C}$    | -4.7   |           | +4.7   |                        |
|                                                        |        | $V_{CC} = 2.7\text{V}$ , $T_A = +125^{\circ}\text{C}$ to $+130^{\circ}\text{C}$    | -5     |           | +5     |                        |
| Output Voltage                                         |        | $T_A = 0^{\circ}\text{C}$                                                          |        | 1.8455    |        | V                      |
| Nonlinearity                                           |        | $T_A = -55^{\circ}\text{C}$ to $+100^{\circ}\text{C}$                              |        | $\pm 0.4$ |        | %                      |
| Sensor Gain (Temperature Sensitivity or Average Slope) |        | $T_A = -20^{\circ}\text{C}$ to $+100^{\circ}\text{C}$ (Note 3)                     | -10.98 | -11.23    | -11.47 | mV/ $^{\circ}\text{C}$ |
| Maximum Output Impedance                               |        | $0 < I_L < 16\mu\text{A}$ , $T_A = -55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$  |        |           | 160    | $\Omega$               |
|                                                        |        | $0 < I_L < 16\mu\text{A}$ , $T_A = +125^{\circ}\text{C}$ to $+130^{\circ}\text{C}$ |        |           | 300    |                        |
| Load Regulation                                        |        | $0 < I_L < 16\mu\text{A}$ , $T_A = -55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$  |        |           | -2.5   | mV                     |
|                                                        |        | $0 < I_L < 16\mu\text{A}$ , $T_A = 125^{\circ}\text{C}$ to $130^{\circ}\text{C}$   |        |           | -4.8   |                        |
| Supply Sensitivity (Note 3)                            |        | $T_A = -20^{\circ}\text{C}$ to $+130^{\circ}\text{C}$ , $V_{CC} \leq 5.5\text{V}$  |        | 1         | 3.3    | mV/V                   |
|                                                        |        | $T_A = -55^{\circ}\text{C}$ to $-20^{\circ}\text{C}$ , $V_{CC} \leq 4.5\text{V}$   |        | 1         | 4.7    |                        |
|                                                        |        | $T_A = -55^{\circ}\text{C}$ to $-20^{\circ}\text{C}$ , $V_{CC} \leq 5.5\text{V}$   |        | 1         |        |                        |
| Quiescent Current                                      | $I_Q$  | No load                                                                            |        | 7.5       | 13     | $\mu\text{A}$          |
| Capacitive Load                                        |        | No sustained oscillations for capacitive loads in this range (Note 4)              | 0      |           | 1000   | pF                     |
| Long-Term Stability                                    |        | $T_A = \text{room temperature for 1000hr}$ (Note 4)                                |        | 0.1       |        | $^{\circ}\text{C}$     |
| Temperature Coefficient of Supply Current              |        |                                                                                    |        | 15        |        | nA/ $^{\circ}\text{C}$ |
| Power-Down Supply Current                              |        | $V_{CC} < 0.8\text{V}$                                                             |        | 0.1       |        | $\mu\text{A}$          |

## Typical Operating Characteristics

( $R_L = \infty\Omega$ ,  $T_A = +30^\circ\text{C}$ , unless otherwise noted.)



## Pin Description

| PIN | NAME     | FUNCTION                                                                   |
|-----|----------|----------------------------------------------------------------------------|
| 1   | N.C.     | No Connection. Must be connected to ground or left unconnected.            |
| 2   | GND      | Ground. Should be connected to pin 5. Can be left unconnected, if desired. |
| 3   | OUT      | Voltage Output                                                             |
| 4   | $V_{CC}$ | Supply Voltage. Bypass to GND with a $0.1\mu\text{F}$ capacitor.           |
| 5   | GND      | Ground                                                                     |

**Table 1. Linear and Quadratic Output Equation**

| PARAMETER                                                                                                 | SYMBOL | CONDITIONS                           | MIN   | TYP | MAX  | UNITS       |
|-----------------------------------------------------------------------------------------------------------|--------|--------------------------------------|-------|-----|------|-------------|
| Temperature Error<br>Based on:<br>$OUT = 1.8639 - 0.0115 \times Temp$<br>(Note 4)                         |        | $V_{CC} = 2.7V, T_A = -55^{\circ}C$  | 0.6   |     | 7.9  | $^{\circ}C$ |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = -20^{\circ}C$  | -0.4  |     | +5.8 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = 0^{\circ}C$    | -0.9  |     | +4.5 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +50^{\circ}C$  | -2.6  |     | +3.0 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +85^{\circ}C$  | -3.6  |     | +3.5 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +100^{\circ}C$ | -4.0  |     | +3.7 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +125^{\circ}C$ | -4.8  |     | +4.2 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +130^{\circ}C$ | -5.1  |     | +4.2 |             |
| Temperature Error<br>Based on:<br>$OUT = 1.8639 - 0.0115 \times Temp - 0.00000388 \times Temp^2$ (Note 4) |        | $V_{CC} = 2.7V, T_A = -55^{\circ}C$  | -0.4  |     | +6.9 | $^{\circ}C$ |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = -20^{\circ}C$  | -0.6  |     | +5.7 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = 0^{\circ}C$    | -0.9  |     | +4.5 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +50^{\circ}C$  | -3.5  |     | +2.1 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +85^{\circ}C$  | -6.1  |     | +1.0 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +100^{\circ}C$ | -7.4  |     | +0.4 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +125^{\circ}C$ | -10.1 |     | -1.0 |             |
|                                                                                                           |        | $V_{CC} = 2.7V, T_A = +130^{\circ}C$ | -10.8 |     | -1.5 |             |

## Detailed Description

The MAX6613 analog output temperature sensor's output voltage is a discrete function of its die temperature. The maximum supply current is 13 $\mu$ A, and the supply voltage range is from 2.5V to 5.5V for the -55 $^{\circ}C$  to +130 $^{\circ}C$  temperature range, or 1.8V to 5.5V for the +25 $^{\circ}C$  to +130 $^{\circ}C$  temperature range.

## Transfer Function

The temperature-to-voltage transfer function is approximately linear and can be described by the quadratic equation:

$$V_{OUT} = -0.00000225 T^2 - 0.01105 \times T + 1.8455V$$

In many cases, a linear approximation can be applied:

$$V_{OUT} = -0.01123 \times T + 1.8455V$$

where T is the die temperature of the MAX6613 in  $^{\circ}C$ .

Therefore:

$$T = (1.8455 - V_{OUT})/0.01123V$$

## Compatibility with Other Temperature Sensors

The MAX6613 can be used to replace temperature sensors using other output algorithms. Table 1 provides information for a linear and quadratic output equation. Contact the factory for performance information about another equation.

Applications Information

Sensing Circuit Board and Ambient Temperature

A temperature sensor IC like the MAX6613 that senses its own die temperature must be mounted on, or close to, the object whose temperature it is intended to measure. Because there is a good thermal path between the package’s metal lead and the IC die, the MAX6613 can accurately measure the temperature of the circuit board to which it is soldered. If the sensor is intended to measure the temperature of a heat-generating component on the circuit board, it should be mounted as close as possible to that component and should share supply and ground traces (if they are not noisy) with that component where possible. This optimizes the thermal connection from the component to the sensor.

The thermal path between the plastic package and the die is not as good as the path through the lead, so the MAX6613, like all temperature sensors in plastic packages, is less sensitive to the temperature of the surrounding air than to the temperature of its leads. It can be successfully used to sense ambient temperature if the circuit board is designed to track the ambient temperature.

As with any IC, the wiring and circuits must be kept insulated and dry to avoid leakage and corrosion, especially if the part is operated at cold temperatures where condensation can occur.

The change in die temperature introduced by the part due to self-heating is negligible.

Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.com/packages). Note that a “+”, “#”, or “-” in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.        |
|--------------|--------------|-------------------------|-------------------------|
| 5 SC70       | X5+1         | <a href="#">21-0076</a> | <a href="#">90-0188</a> |

## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION                                      | PAGES<br>CHANGED |
|--------------------|------------------|--------------------------------------------------|------------------|
| 0                  | 5/02             | Initial release                                  | —                |
| 1                  | 11/03            | Corrected error in equation                      | 4                |
| 2                  | 1/06             | Updated spec in table                            | 2                |
| 3                  | 12/10            | Added lead-free and automotive part, style edits | 1, 2, 3, 5, 6    |
| 4                  | 5/15             | Revised <i>Benefits and Features</i> section     | 1                |

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at [www.maximintegrated.com](http://www.maximintegrated.com).

*Maxim Integrated cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim Integrated product. No circuit patent licenses are implied. Maxim Integrated reserves the right to change the circuitry and specifications without notice at any time. The parametric values (min and max limits) shown in the Electrical Characteristics table are guaranteed. Other parametric values quoted in this data sheet are provided for guidance.*