

## LM66 Dual Output Internally Present Thermostat

### General Description

The LM66 is a precision low power thermostat. Two stable temperature trip points ( $V_{T1}$  and  $V_{T2}$ ) are generated by dividing down the LM66 1.250V bandgap voltage reference using a resistors divider network. The LM66 has two digital outputs. OUT1 goes LOW when the temperature exceeds T1 and goes HIGH when the the temperature goes below ( $T1 - T_{HYST}$ ). Similarly, OUT2 goes LOW when the temperature exceeds T2 and goes HIGH when the temperature goes below ( $T2 - T_{HYST}$ ).  $T_{HYST}$  is an internally set 5°C typical hysteresis.

The LM66 is currently available in an 8-lead small outline package.

### Applications

- Microprocessor Thermal Management
- Appliances
- Portable Battery Powered 3.0V or 5V Systems
- Fan Control
- Industrial Process Control
- HVAC Systems
- Remote Temperature Sensing
- Electronic System Protection

### Features

- Digital outputs support TTL logic levels
- Internal temperature sensor
- 2 internal comparators with hysteresis
- Internal voltage reference
- Currently available in 8-pin SO plastic package

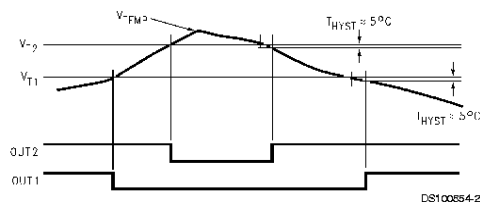
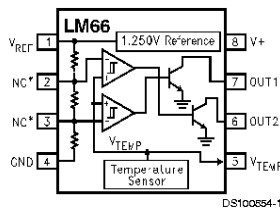
### Key Specifications

- Power Supply Voltage 2.7V to 10V
- Power Supply Current 250  $\mu$ A (max)
- $V_{REF}$  1.250V  $\pm$  1.4% (max)
- Hysteresis Temperature 5°C
- Internal Temperature Sensor  
Output Voltage  $(+6.20 \text{ mV}/^\circ\text{C} \times T) + 400 \text{ mV}$
- Temperature Trip Point Accuracy:

|                | LM66CIM             |
|----------------|---------------------|
| +25°C to +85°C | $\pm 3^\circ$ (max) |

- T1 set point +73°C
- T2 set point +82°C

### Simplified Block Diagram and Connection Diagram

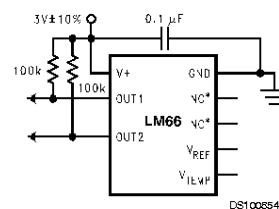


### Ordering Information

TABLE 1.

| Order Number      | LM66CIM-RLSKB | LM66CIMX-RLSKB         |
|-------------------|---------------|------------------------|
| NS Tackage Number | M08A          | M08A                   |
| Transport Media   | Bulk Rail     | 2500 Units Tape & Reel |

### Typical Application



### Absolute Maximum Ratings (Note 1)

|   |        |
|---|--------|
| Input Voltage   | 12V    |
| Input Current at any pin (Note 2)                           | 5 mA   |
| Package Input Current(Note 2)                               | 20 mA  |
| Package Dissipation at $T_A = 25^\circ\text{C}$<br>(Note 3) | 900 mW |
| ESD Susceptibility (Note 4)                                 |        |
| Human Body Model  | 1000V  |
| Machine Model   | 200V   |
| Soldering Information                                       |        |
| SO Package (Note 5) :                                       |        |

|                          |                  |
|--------------------------|------------------|
| Vapor Phase (60 seconds) | 215°C            |
| Infrared (15 seconds)    | 220°C            |
| Storage Temperature      | -65°C to + 150°C |

### Operating Ratings(Note 1)

|                                   |                                  |
|-----------------------------------|----------------------------------|
| Operating Temperature Range       | $T_{MIN} \leq T_A \leq T_{MAX}$  |
| LM66BIM, LM66CIM                  | -40°C $\leq$ $T_A$ $\leq$ +125°C |
| Positive Supply Voltage ( $V^+$ ) | +2.7V to +10V                    |
| Maximum $V_{OUT1}$ and $V_{OUT2}$ | +10V                             |

### LM66 Electrical Characteristics

The following specifications apply for  $V^+ = 2.7 V_{DC}$ , and  $V_{REF}$  load current = 0  $\mu\text{A}$  unless otherwise specified. **Boldface limits apply for  $T_A = T_J = T_{MIN}$  to  $T_{MAX}$** ; all other limits  $T_A = T_J = 25^\circ\text{C}$  unless otherwise specified.

| Symbol                             | Parameter  | Conditions  | Typical<br>(Note 6) | LM66CIM<br>Limits<br>(Note 7)             | Units<br>(Limits)                                |
|------------------------------------|--|---|---------------------|---|--|
| <b>Temperature Sensor</b>          |  |   |                     |   |  |
|                                    | Trip Point Accuracy (Includes $V_{REF}$ , Comparator Offset, and Temperature Sensitivity errors) | $+25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$   |                     | $\pm 3$                                   | $^\circ\text{C}$ (max)                           |
|                                    | Trip Point Hysteresis  | $T_A = +73^\circ\text{C}$   | 6                   | 4.5<br>7.5                                | $^\circ\text{C}$ (min)<br>$^\circ\text{C}$ (max) |
|                                    |  | $T_A = +82^\circ\text{C}$   | 6                   | 4.5<br>7.5                                | $^\circ\text{C}$ (min)<br>$^\circ\text{C}$ (max) |
|                                    | Internal Temperature Sensitivity   |   | +6.20               |   | mV/ $^\circ\text{C}$                             |
|                                    | Temperature Sensitivity Error  | $+25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$   |                     | $\pm 3$                                   | $^\circ\text{C}$ (max)                           |
|                                    |  | $-25^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$  |                     | $\pm 4$                                   | $^\circ\text{C}$ (max)                           |
|                                    |  | $-40^\circ\text{C} \leq T_A \leq -25^\circ\text{C}$   |                     |   | $\pm 3$  |
|                                    | Output Impedance   | $-1 \mu\text{A} \leq I_L \leq +40 \mu\text{A}$  |                     | <b>1500</b>                               | $\Omega$ (max)                                   |
|                                    | Line Regulation  | $+3.0\text{V} \leq V^+ \leq +10\text{V}$ ,<br>$+25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ |                     | <b><math>\pm 0.36</math></b>              | mV/V (max)                                       |
|                                    |  | $+3.0\text{V} \leq V^+ \leq +10\text{V}$ ,<br>$-40^\circ\text{C} \leq T_A < 25^\circ\text{C}$     |                     | <b><math>\pm 0.61</math></b>              | mV/V (max)                                       |
|                                    |  | $+2.7\text{V} \leq V^+ \leq +3.3\text{V}$   |                     |   | <b><math>\pm 2.3</math></b>                      |
| <b><math>V_{REF}</math> Output</b> |  |   |                     |   |  |
| $V_{REF}$                          | $V_{REF}$ Nominal  |   | 1.250V              |   | V  |
|                                    | $V_{REF}$ Error  |   |                     | $\pm 1.4$<br><b><math>\pm 17.5</math></b> | % (max)<br>mV (max)                              |
| $\Delta V_{REF}/\Delta V^+$        | Line Regulation  | $+3.0\text{V} \leq V^+ \leq +10\text{V}$  | 0.13                | <b>0.21</b>                               | mV/V (max)                                       |
|                                    |  | $+2.7\text{V} \leq V^+ \leq +3.3\text{V}$   | 0.15                | <b>1.5</b>                                | mV (max)   |

## LM66 Electrical Characteristics

The following specifications apply for  $V^+ = 2.7 V_{DC}$ , and  $V_{REF}$  load current = 50  $\mu A$  unless otherwise specified. **Boldface limits apply for  $T_A = T_J = T_{MIN}$  to  $T_{MAX}$** ; all other limits  $T_A = T_J = 25^\circ C$  unless otherwise specified.

| Symbol                            | Parameter                          | Conditions            | Typical<br>(Note 6) | Limits<br>(Note 7) | Units<br>(Limits) |
|-----------------------------------|------------------------------------|-----------------------|---------------------|--------------------|-------------------|
| <b>V<sup>+</sup> Power Supply</b> |                                    |                       |                     |                    |                   |
| $I_S$                             | Supply Current                     | $V^+ = +10V$          |                     | <b>250</b>         | $\mu A$ (max)     |
|                                   |                                    | $V^+ = +2.7V$         |                     | <b>250</b>         | $\mu A$ (max)     |
| <b>Digital Output(s)</b>          |                                    |                       |                     |                    |                   |
| $I_{OUT('1')}$                    | Logical "1" Output Leakage Current | $V^+ = +5.0V$         |                     | <b>1</b>           | $\mu A$ (max)     |
| $V_{OUT('0')}$                    | Logical "0" Output Voltage         | $I_{OUT} = +50 \mu A$ |                     | <b>0.4</b>         | V (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 the power supply ( $V_I < GND$  or  $V_I > V^+$ ), the current at that pin should be limited to 5 mA. The 20 mA maximum package input current rating limits the number of pins that can safely exceed the power supplies with an input current of 5 mA to four.

**Note 3:** The maximum power dissipation must be derated at elevated temperatures and is dictated by  $T_{Jmax}$  (maximum junction temperature),  $\theta_{JA}$  (junction to ambient thermal resistance) and  $T_A$  (ambient temperature). The maximum allowable power dissipation at any temperature is  $P_D = (T_{Jmax} - T_A) / \theta_{JA}$  or the number given in the Absolute Maximum Ratings, whichever is lower. For this device,  $T_{Jmax} = 125^\circ C$ . For this device the typical thermal resistance ( $\theta_{JA}$ ) of the different package types when board mounted follow:

| Package Type | $\theta_{JA}$ |
|--------------|---------------|
| M08A         | 110°C/W       |

**Note 4:** The human body model is a 100 pF capacitor discharge through a 1.5 k $\Omega$  resistor into each pin. The machine model is a 200 pF capacitor discharged directly into each pin.

**Note 5:** See AN450 "Surface Mounting Methods and Their Effects on Product Reliability" or the section titled "Surface Mount" found in any post 1986 National Semiconductor Linear Data Book for other methods of soldering surface mount devices.

**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).

**Part Number Template** The series of digits labeled vw xy z in the part number LM66CIM-vw xy z, describe the set points and the function of OUT1 and OUT2 as follows:

The place holders v w describe the set point of T1 as shown in the following table.

The place holders xy describe the set point of T2 as shown in the following table. z=0 (Other assignments are reserved.)

For example the part number LM66CIM-RLSKB has: T1 = 73°C, T2 = 82°C, OUT1 and OUT2 set as active-low open-collector outputs with OUT1 mapped to pin 7 and OUT2 mapped to pin 6.

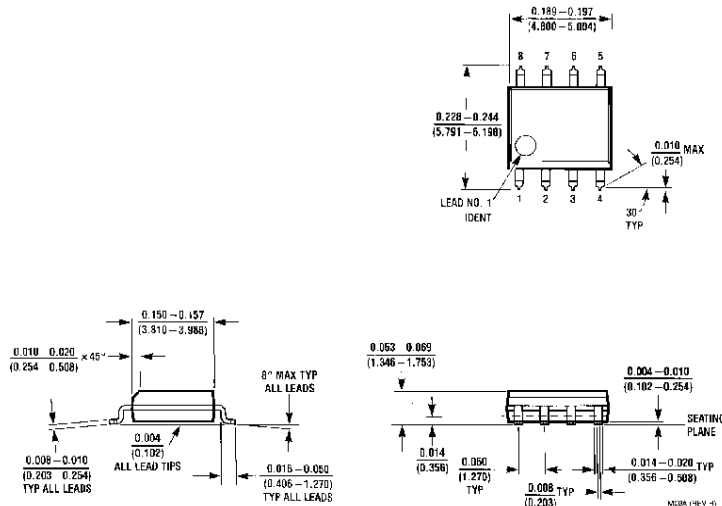
| v, w, x and y | Temperature (°C) |
|---------------|------------------|
| B             | -5               |
| C             | -4               |
| D             | -3               |
| F             | -2               |
| G             | -1               |
| H             | -0               |
| J             | 1                |
| K             | 2                |
| L             | 3                |
| N             | 4                |

| v, w, x and y | Temperature (°C) |
|---------------|------------------|
| P             | 5                |
| Q             | 6                |
| R             | 7                |
| S             | 8                |
| T             | 9                |
| V             | 10               |
| X             | 11               |
| Y             | 12               |
| Z             | 13               |

The value of z describes the assignment/function of OUT1 and OUT2 as shown in the following table:

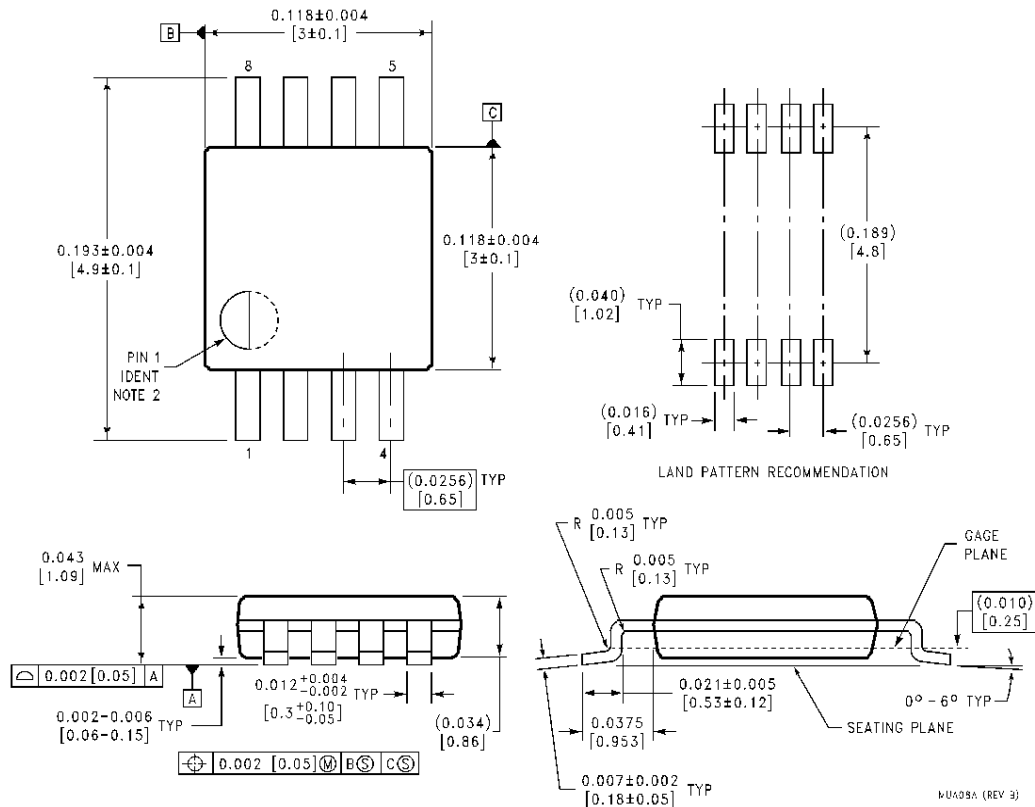
| Active Low/High | Open Collector/Totem Pole | Mapping | Value of z | Function of OUT1 and OUT2   |
|-----------------|---------------------------|---------|------------|---|
| 0               | 0                         | 0       | B          | Active-Low, Open-Collector, OUT1 mapped to pin 7, OUT2 mapped to pin 6  |
| 0               | 0                         | 1       | C          | Active-Low, Open-Collector, OUT1 mapped to pin 6, OUT2 mapped to pin 7  |
| 0               | 1                         | 0       | D          | Active-Low, Totem Pole, OUT1 mapped to pin 7, OUT2 mapped to pin 6      |
| 0               | 1                         | 1       | F          | Active-Low, Totem Pole, OUT1 mapped to pin6, OUT2 mapped to pin 7       |
| 1               | 0                         | 0       | G          | Active-High, Open-Collector, OUT1 mapped to pin 7, OUT2 mapped to pin 6 |
| 1               | 0                         | 1       | H          | Active-High, Open-Collector, OUT1 mapped to pin 6, OUT2 mapped to pin 7 |
| 1               | 1                         | 0       | J          | Active-High, Totem Pole, OUT1 mapped to pin 7, OUT2 mapped to pin 6     |
| 1               | 1                         | 1       | K          | Active-High, Totem Pole, OUT1 mapped to pin6, OUT2 mapped to pin 7      |

**Physical Dimensions** inches (millimeters) unless otherwise noted



**8-Lead (0.150" Wide) Molded Small Outline Package, JEDEC**  
**Order Number LM66BIM, LM66BIMX, LM66CIM or LM66CIMX**  
**NS Package Number M08A**

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



**8-Lead Molded Mini Small Outline Package (MSOP)**  
**(JEDEC REGISTRATION NUMBER M0-187)**  
**Order Number LM66BIMM, LM66BIMMX, LM66CIMM, or LM66CIMMX**  
**NS Package Number MUA08A**

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

**National Semiconductor Corporation**  
Americas  
Tel: 1-800-272-9959  
Fax: 1-800-737-7018  
Email: support@nsc.com

**National Semiconductor Europe**  
Fax: +49 (0) 1 80-530 85 86  
Email: europe.support@nsc.com  
Deutsch Tel: +49 (0) 1 80-530 85 85  
English Tel: +49 (0) 1 80-532 78 32  
Français Tel: +49 (0) 1 80-532 93 58  
Italiano Tel: +49 (0) 1 80-534 16 80

**National Semiconductor Asia Pacific Customer Response Group**  
Tel: 65-2544466  
Fax: 65-2504466  
Email: sea.support@nsc.com

**National Semiconductor Japan Ltd.**  
Tel: 81-3-5639-7560  
Fax: 81-3-5639-7507

www.national.com