

## LM74 SPI/Microwire12-Bit Plus Sign Temperature Sensor

Check for Samples: [LM74](#)

### FEATURES

- 0.0625°C Temperature Resolution
- Shutdown Mode Conserves Power Between Temperature Reading
- SPI and MICROWIRE Bus Interface
- 5-Bump DSBGA Package Saves Space

### APPLICATIONS

- System Thermal Management
- Personal Computers
- Disk Drives
- Office Electronics
- Electronic Test Equipment

### KEY SPECIFICATIONS

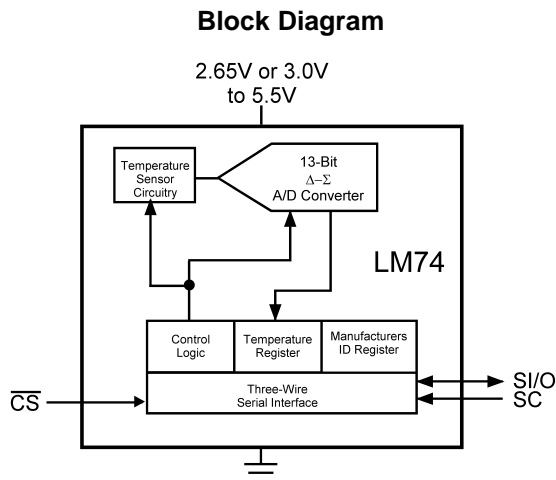
- Supply Voltage 3.0V or 2.65V to 5.5V
- Supply Current
  - Operating
    - 265µA (typ)
    - 520µA (max)
  - Shutdown
    - 3µA (typ)
- Temperature Accuracy
  - -10°C to 65°C, ±1.25°C(max)
  - -25°C to 110°C, ±2.1°C(max)
  - -55°C to 125°C, ±3°C(max)

### DESCRIPTION

The LM74 is a temperature sensor, Delta-Sigma analog-to-digital converter with an SPI and MICROWIRE compatible interface. The host can query the LM74 at any time to read temperature. A shutdown mode decreases power consumption to less than 10 µA. This mode is useful in systems where low average power consumption is critical.

The LM74 has 12-bit plus sign temperature resolution (0.0625°C per LSB) while operating over a temperature range of -55°C to +150°C.

The LM74's 3.0V to 5.5V supply voltage range, low supply current and simple SPI interface make it ideal for a wide range of applications. These include thermal management and protection applications in hard disk drives, printers, electronic test equipment, and office electronics. The LM74 is available in the SOIC package as well as the 5-Bump DSBGA package.



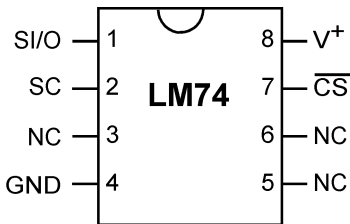
**Figure 1.**



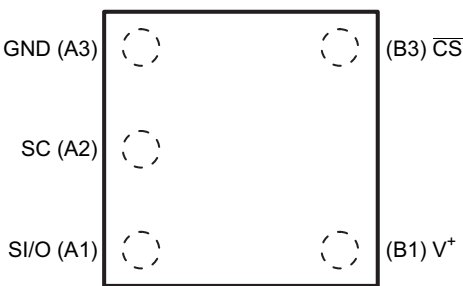
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**Connection Diagram**



**Figure 2. SOIC – Top View**  
See Package Number D

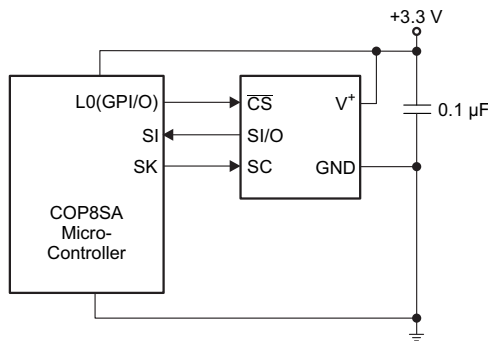


**Figure 3. 5-Bump DSBGA – Top View**  
See Package Number YTA0005

**PIN DESCRIPTIONS**

Label	SOIC Pin #	DSBGA Pin #	Function	Typical Connection
SI/O	1	1	Slave Input/Output - Serial bus bi-directional data line. Schmitt trigger input.	From and to Controller
SC	2	5	Slave Clock - Serial bus clock Schmitt trigger input line.	From Controller
NC	3		No Connection	No Connection
GND	4	4	Power Supply Ground	Ground
NC	5		No Connection	No Connection
NC	6		No Connection	No Connection
$\overline{CS}$	7	3	Chip Select input.	From Controller
V+	8	2	Positive Supply Voltage Input	DC Voltage from 3.0V to 5.5V for the LM74CIM and 2.65V to 5.5V for the LM74CIBP and LM74CITP. Bypass with a 0.1 $\mu$ F ceramic capacitor.

**Typical Application**



**Figure 4. COP Microcontroller Interface**



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## Absolute Maximum Ratings<sup>(1)</sup>

Supply Voltage	–0.3V to 6.0V
Voltage at any Pin	–0.3V to $V^+$ + 0.3V
Input Current at any Pin <sup>(2)</sup>	5 mA
Package Input Current <sup>(2)</sup>	20 mA
Storage Temperature	–65°C to +150°C
ESD Susceptibility <sup>(3)</sup>	
Human Body Model	
LM74CIBP and LM74CITP, pin A2 (SC)	1900V
LM74CIM, LM74CIBP, and LM74CITP all other pins	2000V
Machine Model	200V
<i>Soldering process must comply with Reflow Temperature Profile specifications. See <a href="http://www.ti.com/packaging">www.ti.com/packaging</a>.<sup>(4)</sup></i>	

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions.
- (2) When the input voltage ( $V_I$ ) at any pin exceeds the power supplies ( $V_I < \text{GND}$  or  $V_I > +V_S$ ) 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.
- (3) Human body model, 100 pF discharged through a 1.5 k $\Omega$  resistor. Machine model, 200 pF discharged directly into each pin.
- (4) Reflow temperature profiles are different for lead-free and non-lead-free packages.

## Operating Ratings

Specified Temperature Range	$T_{\text{MIN}}$ to $T_{\text{MAX}}$
See <sup>(1)</sup> LM74CIBP and LM74CITP LM74CIM	–40°C to +125°C –55°C to +150°C
Supply Voltage Range (+ $V_S$ )	
LM74CIBP and LM74CITP	+2.65V to +5.5V
LM74CIM	+3.0V to +5.5V

- (1) The life expectancy of the LM74 will be reduced when operating at elevated temperatures. LM74  $\theta_{JA}$  (thermal resistance, junction-to-ambient) when attached to a printed circuit board with 2 oz. foil is summarized as: Device Number LM74CIM Thermal Resistance ( $\theta_{JA}$ ) 160°C/W. Device Number LM74CIBP Thermal Resistance ( $\theta_{JA}$ ) 250°C/W. Device Number LM74CITP Thermal Resistance ( $\theta_{JA}$ ) 250°C/W.

## Temperature-to-Digital Converter Characteristics

Unless otherwise noted, these specifications apply for  $V^+ = 2.65\text{V}$  to  $3.6\text{V}$  for the LM74CIBP -3, LM74CITP-3,  $V^+ = 3.0\text{V}$  to  $3.6\text{V}$  for the LM74CIM -3 and  $V^+ = 4.5\text{V}$  to  $5.5\text{V}$  for the LM74 -5<sup>(1)</sup>. **Boldface limits apply for  $T_A = T_J = T_{\text{MIN}}$  to  $T_{\text{MAX}}$** ; all other limits  $T_A = T_J = +25^\circ\text{C}$ , unless otherwise noted.

Parameter		Conditions	Typical <sup>(2)</sup>	LM74-5 Limits <sup>(3)</sup>	LM74-3 Limits <sup>(3)</sup>	Units (Limit)
Temperature Error <sup>(1)</sup>		$T_A = -10^\circ\text{C}$ to $+65^\circ\text{C}$		<b><math>\pm 1.25</math></b>	<b><math>\pm 1.25</math></b>	$^\circ\text{C}$ (max)
		$T_A = -25^\circ\text{C}$ to $+110^\circ\text{C}$		<b><math>\pm 2.1</math></b>	<b><math>+2.65/-2.15</math></b>	$^\circ\text{C}$ (max)
		$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$		<b><math>+2.65/-1.65</math></b>	<b><math>\pm 2.15</math></b>	$^\circ\text{C}$ (max)
		$T_A = -40^\circ\text{C}$ to $+110^\circ\text{C}$		<b><math>+2.65/-2.0</math></b>	<b><math>+2.65/-2.15</math></b>	$^\circ\text{C}$ (max)
		$T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$		<b><math>\pm 3.0</math></b>	<b><math>\pm 3.5</math></b>	$^\circ\text{C}$ (max)
		$T_A = -55^\circ\text{C}$ to $+150^\circ\text{C}$		<b><math>\pm 5.0</math></b>	<b><math>\pm 5.0</math></b>	$^\circ\text{C}$ (max)
Resolution			13			Bits
Temperature Conversion Time	SOIC	See <sup>(4)</sup>	280	<b>425</b>	<b>425</b>	ms (max)
	DSBGA	See <sup>(4)</sup>	611	<b>925</b>	<b>925</b>	ms (max)
Quiescent Current	SOIC	Serial Bus Inactive	310	<b>520</b>	<b>520</b>	$\mu\text{A}$ (max)
	DSBGA		265	<b>470</b>	<b>470</b>	$\mu\text{A}$ (max)
	SOIC	Serial Bus Active	310			$\mu\text{A}$
	DSBGA		310			$\mu\text{A}$
	SOIC	Shutdown Mode, $V^+ = 3.3\text{V}$	7			$\mu\text{A}$
	DSBGA		3			$\mu\text{A}$
	SOIC	Shutdown Mode, $V^+ = 5\text{V}$	8			$\mu\text{A}$
	DSBGA		4			$\mu\text{A}$

- (1) All SOP (LM74CIM) parts will function over the  $V^+$  supply voltage range of  $3\text{V}$  to  $5.5\text{V}$ . All DSBGA (LM74SIBP and LM75CITP) parts will function over the  $V^+$  supply voltage range of  $2.65\text{V}$  to  $5.5\text{V}$ . The SOP (LM74CIM) parts are tested and specified for rated temperature error at their nominal supply voltage for temperature ranges of  $-10^\circ\text{C}$  to  $+65^\circ\text{C}$ ,  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$ . For the SOP (LM74CIM) parts, the temperature error specifications for temperature ranges of  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $-25^\circ\text{C}$  to  $+110^\circ\text{C}$ , and  $-40^\circ\text{C}$  to  $+110^\circ\text{C}$  include error induced by power supply variation of  $\pm 5\%$  from the nominal value. For the LM74CIM (SOP) parts, the temperature error will increase by  $\pm 0.3^\circ\text{C}$  for a power supply voltage ( $V^+$ ) variation of  $\pm 10\%$  from the nominal value. For the LM74CIBP-3 and LM74CITP-3 (DSBGA) parts all accuracies are ensured over the supply range of  $2.65\text{V}$  to  $3.6\text{V}$ , except for the temperature ranges of  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$  where the accuracy applies for the nominal supply voltage of  $3.3\text{V}$ . For the LM74CIBP-5 and LM74CITP-5 (DSBGA) parts all accuracies are guaranteed over the supply range of  $4.75\text{V}$  to  $5.25\text{V}$ , except for the temperature ranges of  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$  where the accuracy applies for the nominal supply voltage of  $5.0\text{V}$ . For the LM74CIBP and LM74CITP over  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$ , a power supply variation of  $\pm 10\%$  will degrade the accuracy by  $\pm 0.3^\circ\text{C}$ .
- (2) Typicals are at  $T_A = 25^\circ\text{C}$  and represent most likely parametric norm.
- (3) Limits are specified to AOQL (Average Outgoing Quality Level).
- (4) This specification is provided only to indicate how often temperature data is updated. The LM74 can be read at any time without regard to conversion state (and will yield last conversion result). A conversion in progress will not be interrupted. The output shift register will be updated at the completion of the read and a new conversion restarted.

## Logic Electrical Characteristics

### DIGITAL DC CHARACTERISTICS

Unless otherwise noted, these specifications apply for  $V^+ = 2.65\text{V}$  to  $3.6\text{V}$  for the LM74CIBP -3, LM74CITP-3,  $V^+ = 3.0\text{V}$  to  $3.6\text{V}$  for the LM74CIM -3 and  $V^+ = 4.5\text{V}$  to  $5.5\text{V}$  for the LM74 -5<sup>(1)</sup>. **Boldface limits apply for  $T_A = T_J = T_{\text{MIN}}$  to  $T_{\text{MAX}}$** ; all other limits  $T_A = T_J = +25^\circ\text{C}$ , unless otherwise noted.

Symbol	Parameter	Conditions	Typical <sup>(2)</sup>	Limits <sup>(3)</sup>	Units (Limit)
$V_{\text{IN}(1)}$	Logical "1" Input Voltage			$V^+ \times 0.7$	V (min)
				$V^+ + 0.3$	V (max)
$V_{\text{IN}(0)}$	Logical "0" Input Voltage			$-0.3$	V (min)
				$V^+ \times 0.3$	V (max)
	Input Hysteresis Voltage	$V^+ = 3.0\text{V}$ to $3.6\text{V}$	0.8	<b>0.35</b>	V (min)
		$V^+ = 4.5\text{V}$ to $5.5\text{V}$	0.8	<b>0.33</b>	V (min)
$I_{\text{IN}(1)}$	Logical "1" Input Current	$V_{\text{IN}} = V^+$	0.005	<b>3.0</b>	$\mu\text{A}$ (max)
$I_{\text{IN}(0)}$	Logical "0" Input Current	$V_{\text{IN}} = 0\text{V}$	-0.005	<b>-3.0</b>	$\mu\text{A}$ (min)
$C_{\text{IN}}$	All Digital Inputs		20		pF
$V_{\text{OH}}$	High Level Output Voltage	$I_{\text{OH}} = -400\ \mu\text{A}$		<b>2.4</b>	V (min)
$V_{\text{OL}}$	Low Level Output Voltage	$I_{\text{OL}} = +2\ \text{mA}$		<b>0.4</b>	V (max)
$I_{\text{O\_TRI-STATE}}$	TRI-STATE Output Leakage Current	$V_{\text{O}} = \text{GND}$ $V_{\text{O}} = V^+$		<b>-1</b> <b>+1</b>	$\mu\text{A}$ (min) $\mu\text{A}$ (max)

- (1) All SOP (LM74CIM) parts will function over the  $V^+$  supply voltage range of  $3\text{V}$  to  $5.5\text{V}$ . All DSBGA (LM74SIBP and LM75CITP) parts will function over the  $V^+$  supply voltage range of  $2.65\text{V}$  to  $5.5\text{V}$ . The SOP (LM74CIM) parts are tested and specified for rated temperature error at their nominal supply voltage for temperature ranges of  $-10^\circ\text{C}$  to  $+65^\circ\text{C}$ ,  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$ . For the SOP (LM74CIM) parts, the temperature error specifications for temperature ranges of  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $-25^\circ\text{C}$  to  $+110^\circ\text{C}$ , and  $-40^\circ\text{C}$  to  $+110^\circ\text{C}$  include error induced by power supply variation of  $\pm 5\%$  from the nominal value. For the LM74CIM (SOP) parts, the temperature error will increase by  $\pm 0.3^\circ\text{C}$  for a power supply voltage ( $V^+$ ) variation of  $\pm 10\%$  from the nominal value. For the LM74CIBP-3 and LM74CITP-3 (DSBGA) parts all accuracies are ensured over the supply range of  $2.65\text{V}$  to  $3.6\text{V}$ , except for the temperature ranges of  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$  where the accuracy applies for the nominal supply voltage of  $3.3\text{V}$ . For the LM74CIBP-5 and LM74CITP-5 (DSBGA) parts all accuracies are guaranteed over the supply range of  $4.75\text{V}$  to  $5.25\text{V}$ , except for the temperature ranges of  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$  where the accuracy applies for the nominal supply voltage of  $5.0\text{V}$ . For the LM74CIBP and LM74CITP over  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$ , a power supply variation of  $\pm 10\%$  will degrade the accuracy by  $\pm 0.3^\circ\text{C}$ .
- (2) Typicals are at  $T_A = 25^\circ\text{C}$  and represent most likely parametric norm.
- (3) Limits are specified to AOQL (Average Outgoing Quality Level).

### SERIAL BUS DIGITAL SWITCHING CHARACTERISTICS

Unless otherwise noted, these specifications apply for  $V^+ = 2.65\text{V}$  to  $3.6\text{V}$  for the LM74CIBP -3, LM74CITP-3,  $V^+ = 3.0\text{V}$  to  $3.6\text{V}$  for the LM74CIM -3 and  $V^+ = 4.5\text{V}$  to  $5.5\text{V}$  for the LM74 -5<sup>(1)</sup>;  $C_L$  (load capacitance) on output lines =  $100\text{ pF}$  unless otherwise specified. **Boldface limits apply for  $T_A = T_J = T_{\text{MIN}}$  to  $T_{\text{MAX}}$** ; all other limits  $T_A = T_J = +25^\circ\text{C}$ , unless otherwise noted.

Symbol	Parameter	Conditions	Typical <sup>(2)</sup>	Limits <sup>(3)</sup>	Units (Limit)
$t_1$	SC (Clock) Period			<b>0.16</b> DC	$\mu\text{s}$ (min) (max)
$t_2$	$\overline{\text{CS}}$ Low to SC (Clock) High Set-Up Time			<b>100</b>	ns (min)
$t_3$	$\overline{\text{CS}}$ Low to Data Out (SO) Delay			<b>70</b>	ns (max)
$t_4$	SC (Clock) Low to Data Out (SO) Delay			<b>100</b>	ns (max)
$t_5$	$\overline{\text{CS}}$ High to Data Out (SO) TRI-STATE			<b>200</b>	ns (max)
$t_6$	SC (Clock) High to Data In (SI) Hold Time			<b>50</b>	ns (min)
$t_7$	Data In (SI) Set-Up Time to SC (Clock) High			<b>30</b>	ns (min)

- (1) All SOP (LM74CIM) parts will function over the  $V^+$  supply voltage range of  $3\text{V}$  to  $5.5\text{V}$ . All DSBGA (LM74SIBP and LM75CITP) parts will function over the  $V^+$  supply voltage range of  $2.65\text{V}$  to  $5.5\text{V}$ . The SOP (LM74CIM) parts are tested and specified for rated temperature error at their nominal supply voltage for temperature ranges of  $-10^\circ\text{C}$  to  $+65^\circ\text{C}$ ,  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$ . For the SOP (LM74CIM) parts, the temperature error specifications for temperature ranges of  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $-25^\circ\text{C}$  to  $+110^\circ\text{C}$ , and  $-40^\circ\text{C}$  to  $+110^\circ\text{C}$  include error induced by power supply variation of  $\pm 5\%$  from the nominal value. For the LM74CIM (SOP) parts, the temperature error will increase by  $\pm 0.3^\circ\text{C}$  for a power supply voltage ( $V^+$ ) variation of  $\pm 10\%$  from the nominal value. For the LM74CIBP-3 and LM74CITP-3 (DSBGA) parts all accuracies are ensured over the supply range of  $2.65\text{V}$  to  $3.6\text{V}$ , except for the temperature ranges of  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$  where the accuracy applies for the nominal supply voltage of  $3.3\text{V}$ . For the LM74CIBP-5 and LM74CITP-5 (DSBGA) parts all accuracies are guaranteed over the supply range of  $4.75\text{V}$  to  $5.25\text{V}$ , except for the temperature ranges of  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$  where the accuracy applies for the nominal supply voltage of  $5.0\text{V}$ . For the LM74CIBP and LM74CITP over  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  and  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$ , a power supply variation of  $\pm 10\%$  will degrade the accuracy by  $\pm 0.3^\circ\text{C}$ .
- (2) Typicals are at  $T_A = 25^\circ\text{C}$  and represent most likely parametric norm.
- (3) Limits are specified to AOQL (Average Outgoing Quality Level).

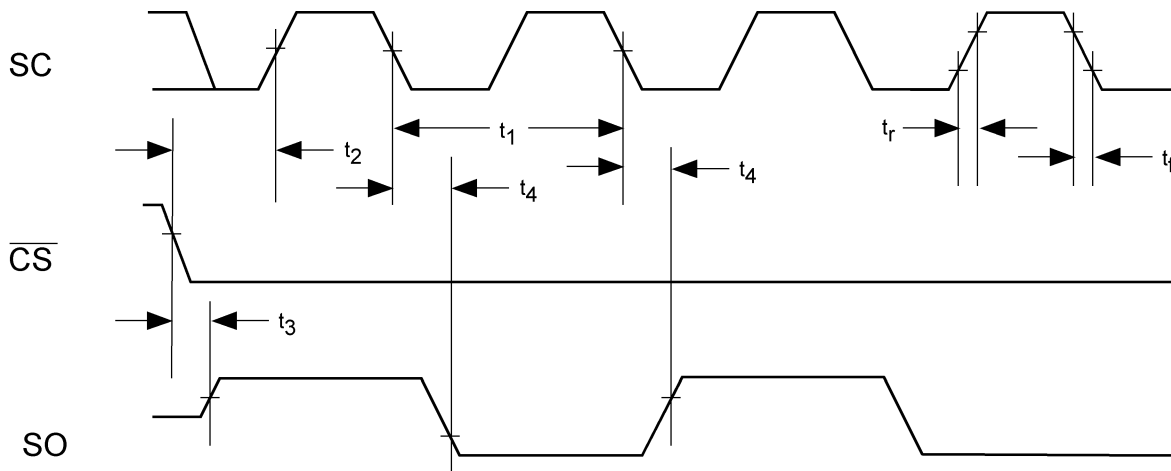


Figure 5. Data Output Timing Diagram

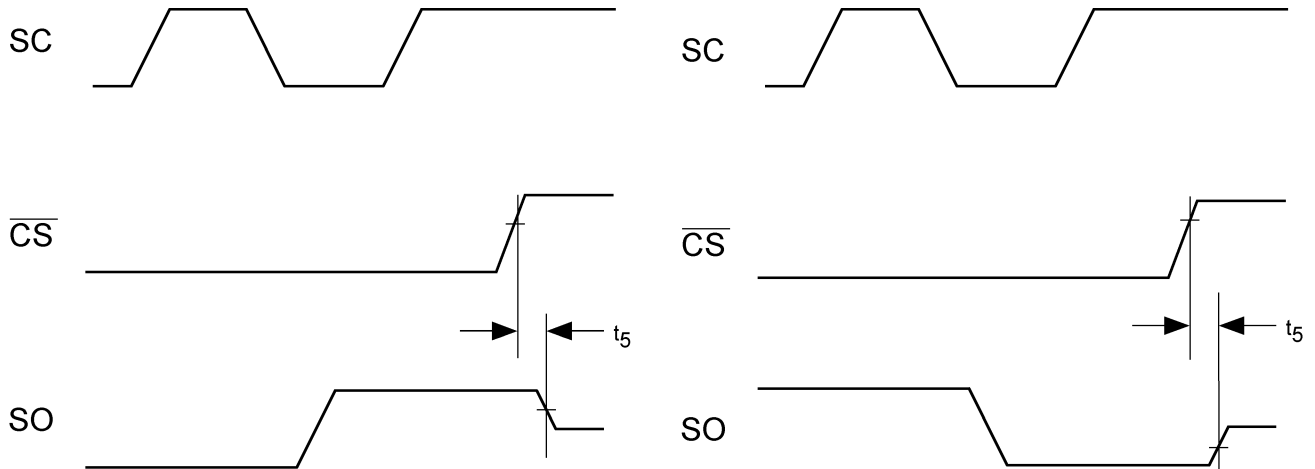


Figure 6. TRI-STATE Data Output Timing Diagram

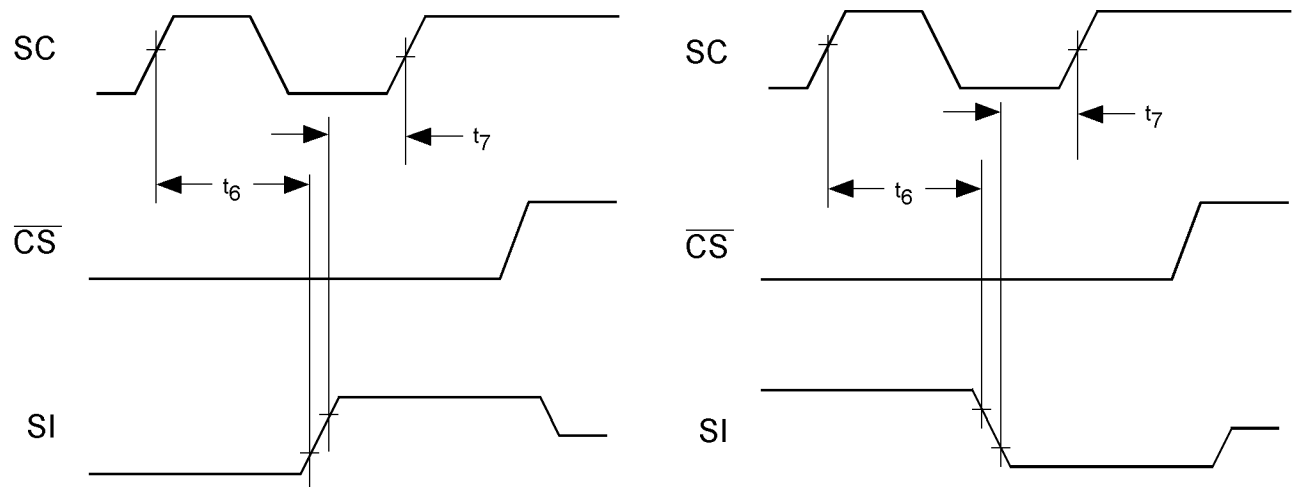


Figure 7. Data Input Timing Diagram

## Electrical Characteristics

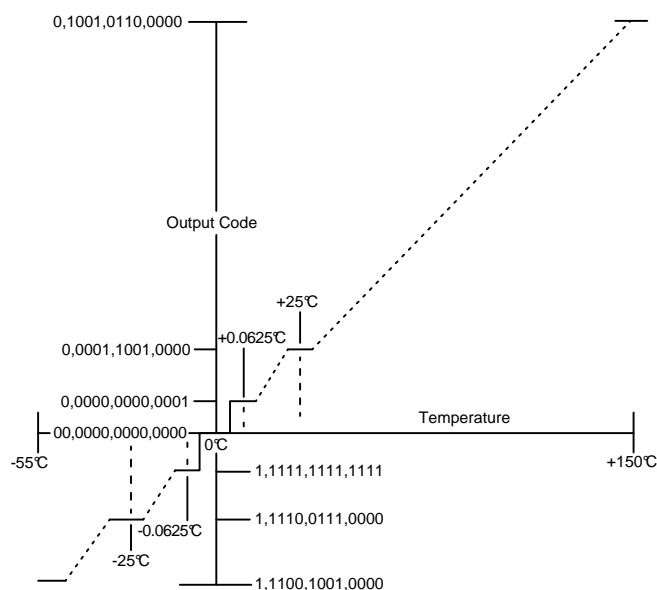


Figure 8. Temperature-to-Digital Transfer Function (Non-linear scale for clarity)

## TRI-STATE Test Circuit

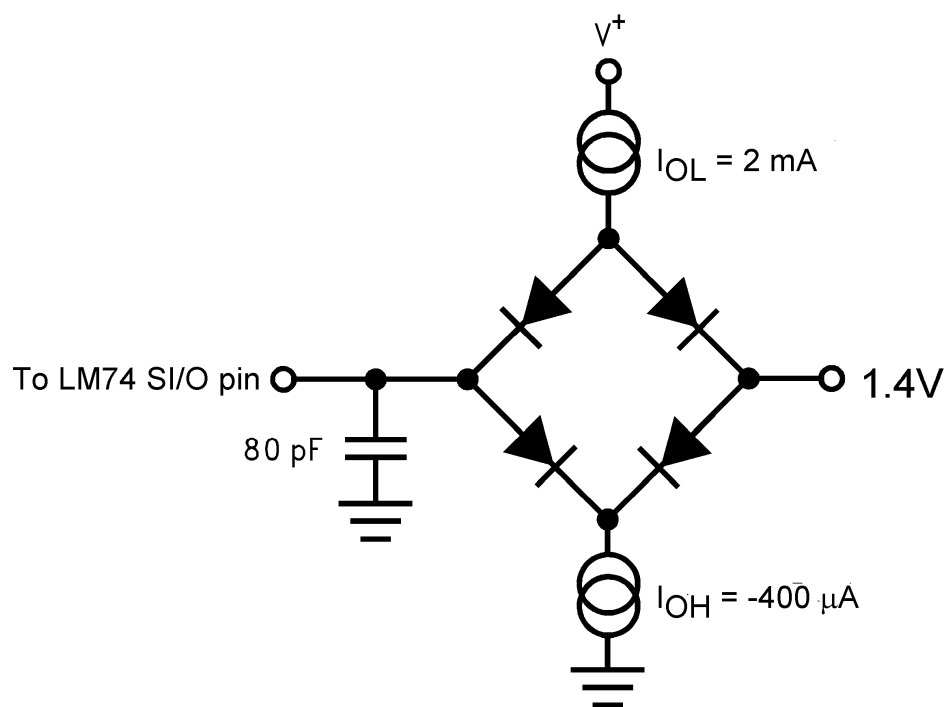


Figure 9.

## Typical Performance Characteristics

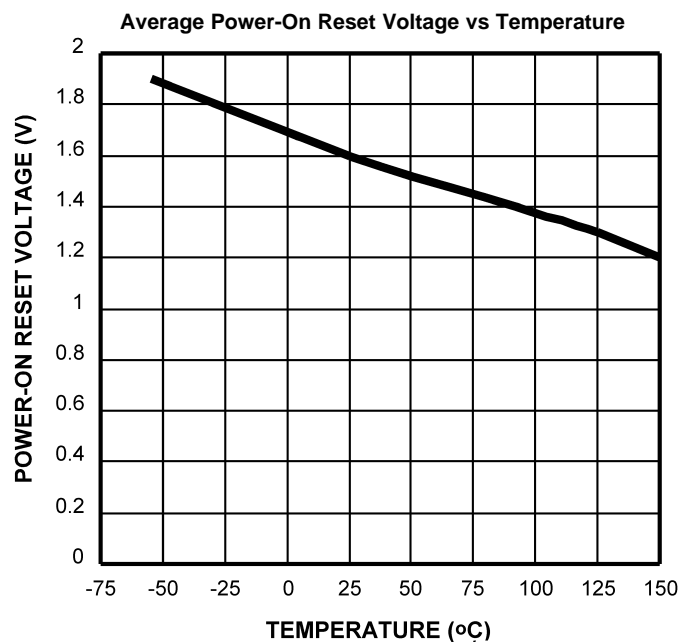


Figure 10.

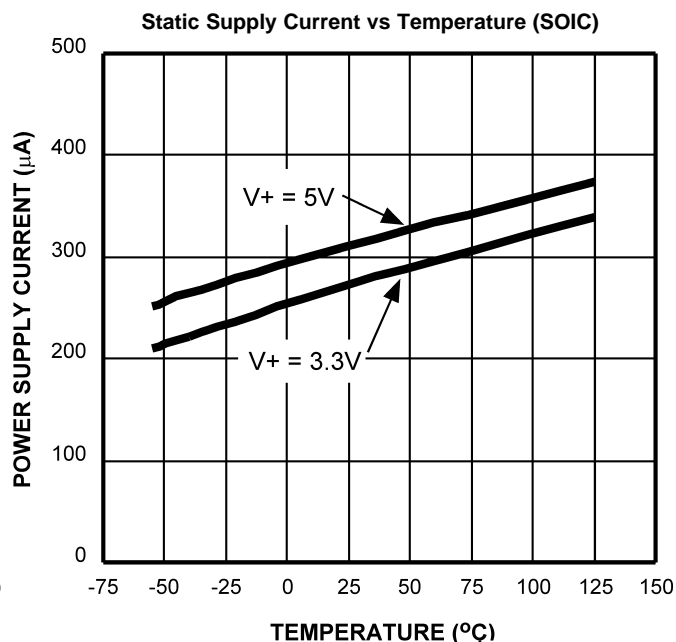


Figure 11.

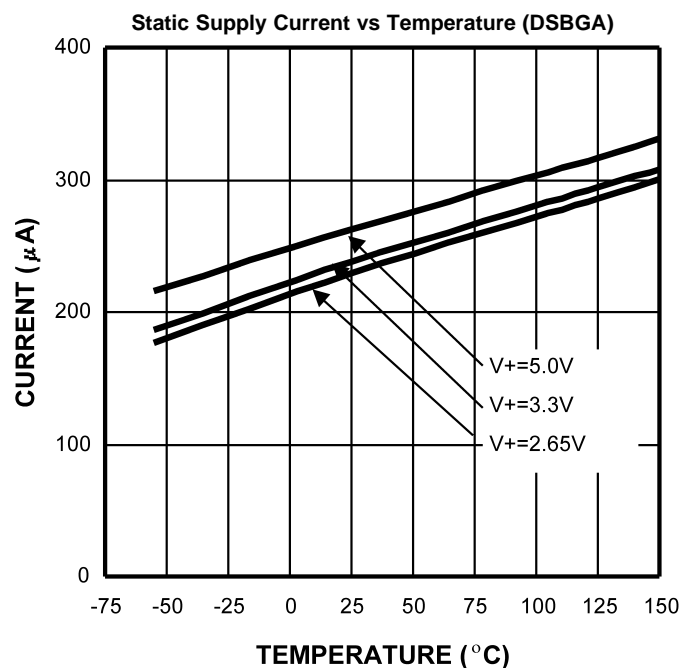


Figure 12.

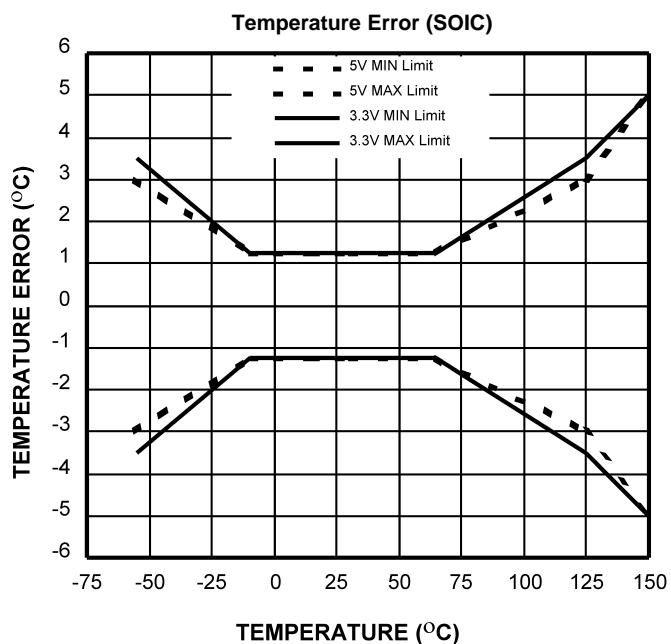


Figure 13.

## FUNCTIONAL DESCRIPTION

The LM74 temperature sensor incorporates a band-gap type temperature sensor and 12-bit plus sign  $\Delta\Sigma$  ADC (Delta-Sigma Analog-to-Digital Converter). Compatibility of the LM74's three wire serial interface with SPI and MICROWIRE allows simple communications with common microcontrollers and processors. Shutdown mode can be used to optimize current drain for different applications. A Manufacture's/Device ID register identifies the LM74 as Texas Instruments product.

### Power Up and Power Down

When the supply voltage is less than about 1.6V (typical), the LM74 is considered powered down. The LM74 always powers up in a known state. When the supply voltage rises above 1.6V (typical), an internal Power-On Reset (POR) occurs and the temperature register will then contain a value of 1111 1111 0000 00XX, where XX indicates undefined values. See [Temperature Register \(after power-up, before first complete temperature conversion\)](#) diagram for contents after POR but before completion of the first temperature conversion.

The LM74 power-up default condition is continuous conversion mode. After completion of the first full temperature conversion, the register will contain temperature measurement data in bits D15 (the temperature data MSB) through D3 (the temperature data LSB). Bit D2 will be fixed high; bits D1 and D0 are undefined. See Section 1.5.3 for a diagram of the Temperature Register contents after the first complete temperature conversion. Note that bit D2 represents a complete conversion flag. During POR it is low and, after the first temperature conversion is complete, it goes high. This bit can be polled to indicate when the POR data in the Temperature Register has been replaced with valid temperature data.

After the first conversion, and any subsequent conversions, the value in the temperature register does not change until the completion of the next conversion, at which time the temperature register is updated with the latest temperature value.

### Serial Bus Interface

The LM74 operates as a slave and is compatible with SPI or MICROWIRE bus specifications. Data is clocked out on the falling edge of the serial clock (SC), while data is clocked in on the rising edge of SC. A complete transmit/receive communication will consist of 32 serial clocks. The first 16 clocks comprise the transmit phase of communication, while the second 16 clocks are the receive phase.

When  $\overline{CS}$  is high SI/O will be in TRI-STATE. Communication should be initiated by taking chip select ( $\overline{CS}$ ) low. This should not be done when SC is changing from a low to high state. Once  $\overline{CS}$  is low the serial I/O pin (SI/O) will transmit the first bit of data. The master can then read this bit with the rising edge of SC. The remainder of the data will be clocked out by the falling edge of SC. Once the 14 bits of data (one sign bit, twelve temperature bits and 1 high bit) are transmitted the SI/O line will go into TRI-STATE.  $\overline{CS}$  can be taken high at any time during the transmit phase. If  $\overline{CS}$  is brought low in the middle of a conversion the LM74 will complete the conversion and the output shift register will be updated after  $\overline{CS}$  is brought back high.

The receive phase of a communication starts after 16 SC periods.  $\overline{CS}$  can remain low for 32 SC cycles. The LM74 will read the data available on the SI/O line on the rising edge of the serial clock. Input data is to an 8-bit shift register. The part will detect the last eight bits shifted into the register. The receive phase can last up to 16 SC periods. All ones must be shifted in order to place the part into shutdown. A zero in any location will take the LM74 out of shutdown. The following codes should only be transmitted to the LM74:

- 00 hex
- 01 hex
- 03 hex
- 07 hex
- 0F hex
- 1F hex
- 3F hex
- 7F hex
- FF hex

any others may place the part into a Test Mode. Test Modes are used by Texas Instruments to thoroughly test the function of the LM74 during production testing. Only eight bits have been defined above since only the last eight transmitted are detected by the LM74, before  $\overline{CS}$  is taken HIGH.

The following communication can be used to determine the Manufacturer's/Device ID and then immediately place the part into continuous conversion mode. With  $\overline{CS}$  continuously low:

- Read 16 bits of temperature data
- Write 16 bits of data commanding shutdown
- Read 16 bits of Manufacturer's/Device ID data
- Write 8 to 16 bits of data commanding Conversion Mode
- Take  $\overline{CS}$  HIGH.

Note that one complete temperature conversion period will have to pass before the LM74 Temperature register will contain the new temperature data. Until then, it will contain a "stale" temperature (the data that was in the register before going into shutdown mode).

## Temperature Data Format

Temperature data is represented by a 13-bit, two's complement word with an LSB (Least Significant Bit) equal to 0.0625°C:

Temperature	Digital Output	
	Binary	Hex
+150°C	0100 1011 0000 0111	4B 07h
+125°C	0011 1110 1000 0111	3E 87h
+25°C	0000 1100 1000 0111	0C 87h
+0.0625°C	0000 0000 0000 1111	00 0Fh
0°C	0000 0000 0000 0111	00 07h
-0.0625°C	1111 1111 1111 1111	FF FFh
-25°C	1111 0011 1000 0111	F3 87h
-55°C	1110 0100 1000 0111	E4 87h

Note: The last two bits are TRI-STATE and depicted as one in the table.

The first data byte is the most significant byte with most significant bit first, permitting only as much data as necessary to be read to determine temperature condition. For instance, if the first four bits of the temperature data indicate an overtemperature condition, the host processor could immediately take action to remedy the excessive temperatures.

## Shutdown Mode/Manufacturer's ID

Shutdown mode is enabled by writing XX FF to the LM74 as shown in [Figure 16c](#). The serial bus is still active when the LM74 is in shutdown. Current draw drops to less than 10  $\mu$ A between serial communications. When in shutdown mode the LM74 always will output 1000 0000 0000 00XX. This is the manufacturer's/Device ID information. The first 5-bits of the field (1000 0XXX) are reserved for manufacturer's ID. As mentioned in Section 1.2, writing a zero to the LM74 configuration register will take it out of shutdown mode and place it in conversion mode. In other words, any valid code listed in Section 1.2 other than XX FF will put it in conversion mode. After leaving shutdown, but before the first temperature conversion is complete, the temperature register will contain the last measured temperature which resided in the temperature register before entering shutdown mode. After the completion of the first conversion, the temperature register will be updated with the new temperature data.

## Internal Register Structure

The LM74 has three registers, the temperature register, the configuration register and the manufacturer's/device identification register. The temperature and manufacturer's/device identification registers are read only. The configuration register is write only.

## Configuration Register

(Selects shutdown or continuous conversion modes):

**Table 1. (Write Only):**

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
X	X	X	X	X	X	X	X	Shutdown							

D0–D15 set to XX FF hex enables shutdown mode.

D0–D15 set to 00 00 hex sets Continuous conversion mode.

Note: setting D0-D15 to any other values may place the LM74 into a manufacturer's test mode, upon which the LM74 will stop responding as described. These test modes are to be used for Texas Instruments production testing only. See [Serial Bus Interface](#) for a complete discussion.

### Temperature Register (after power-up, before first complete temperature conversion)

**Table 2. (Read Only):**

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	1	1	1	1	1	1	1	0	0	0	0	0	0	X	X

D0–D1: Undefined. TRI-STATE will be output on SI/O.

D2–D15: Power-on Reset (POR) values.

### Temperature Register (after completion of first temperature conversion)

**Table 3. (Read Only):**

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
MSB	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	LSB	1	X	X

D0–D1: Undefined. TRI-STATE will be output on SI/O.

D2: High.

D3–D15: Temperature Data. One LSB = 0.0625°C. Two's complement format.

### Manufacturer's Device ID Register

**Table 4. (Read Only):**

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	X	X

D0–D1: Undefined. TRI-STATE will be output on SI/O.

D2–D15: Manufacturer's/Device ID Data. This register is accessed whenever the LM74 is in shutdown mode.

## Serial Bus Timing Diagrams

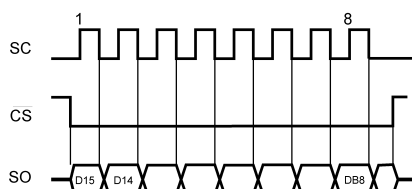


Figure 14. a) Reading Continuous Conversion - Single Eight-Bit Frame

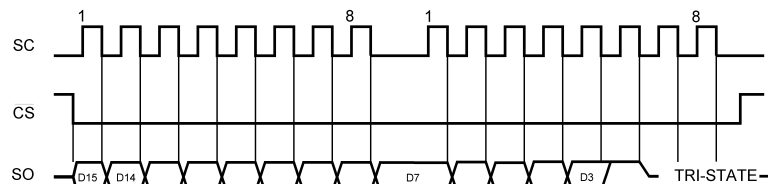


Figure 15. b) Reading Continuous Conversion - Two Eight-Bit Frames

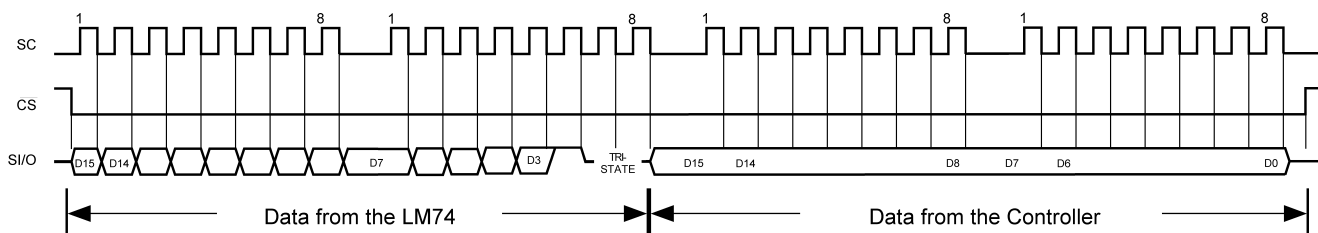


Figure 16. c) Writing Shutdown Control

## Application Hints

To get the expected results when measuring temperature with an integrated circuit temperature sensor like the LM74, it is important to understand that the sensor measures its own die temperature. For the LM74, the best thermal path between the die and the outside world is through the LM74's pins. In the SOIC package all the pins on the LM74 will have an equal effect on the die temperature. Because the pins represent a good thermal path to the LM74 die, the LM74 will provide an accurate measurement of the temperature of the printed circuit board on which it is mounted. There is a less efficient thermal path between the plastic package and the LM74 die. If the ambient air temperature is significantly different from the printed circuit board temperature, it will have a small effect on the measured temperature.

In probe-type applications, the LM74 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 LM74 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. Printed-circuit coatings and varnishes such as Humiseal and epoxy paints or dips are often used to insure that moisture cannot corrode the LM74 or its connections.

## DSBGA Light Sensitivity

The LM74 in the DSBGA package should not be exposed to ultraviolet light. The DSBGA package does not completely encapsulate the LM74 die in epoxy. Exposing the LM74 DSBGA package to bright sunlight will not immediately cause a change in the output reading. Our experiments show that directly exposing the circuit side (bump side) of the die to high intensity ( $\geq 1 \text{ mW/cm}^2$ ) ultraviolet light, centered at a wavelength of 254nm, for greater than 20 minutes will deprogram the EEPROM cells in the LM74. Since the EEPROM is used for storing calibration coefficients, the LM74 will function but the temperature accuracy will no longer be as specified. Light can penetrate through the side of the package as well, so exposure to ultra violet radiation is not recommended even after mounting.

## Typical Applications

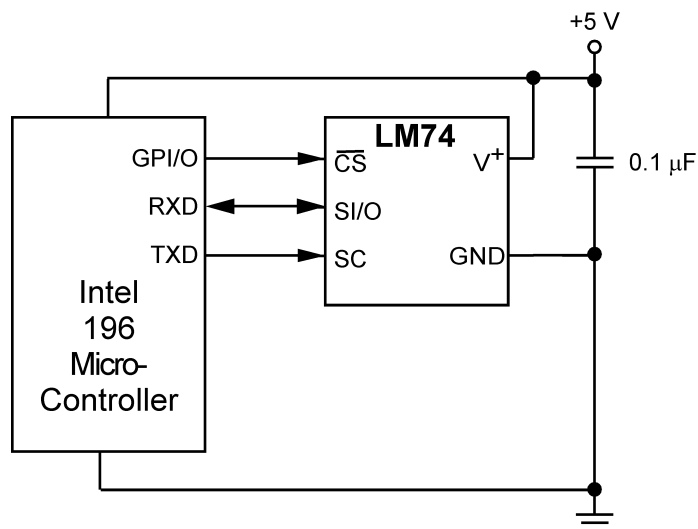


Figure 17. Temperature monitor using Intel 196 processor

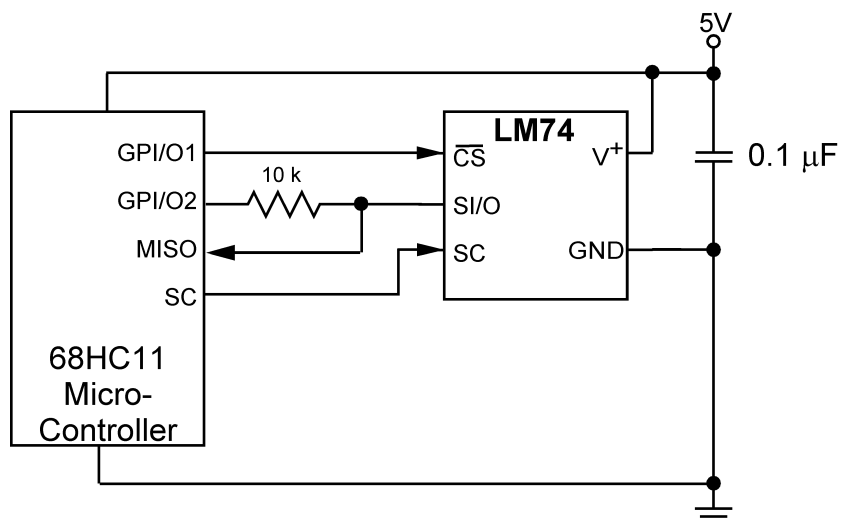


Figure 18. LM74 digital input control using microcontroller's general purpose I/O.

## REVISION HISTORY

Changes from Revision J (March 2013) to Revision K	Page
• Changed layout of National Data Sheet to TI format .....	<a href="#">14</a>

## PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM74CIM-3	Last Time Buy	Production	SOIC (D)   8	95   TUBE	No	SNPB	Level-1-235C-UNLIM	-55 to 150	LM74 CIM3
<a href="#">LM74CIM-3/NOPB</a>	Obsolete	Production	SOIC (D)   8	-	-	Call TI	Call TI	-55 to 150	LM74 CIM3
LM74CIM-5	NRND	Production	SOIC (D)   8	95   TUBE	No	SNPB	Level-1-235C-UNLIM	-55 to 150	LM74 CIM5
LM74CIM-5.A	NRND	Production	SOIC (D)   8	95   TUBE	No	SNPB	Level-1-235C-UNLIM	-55 to 150	LM74 CIM5
<a href="#">LM74CIM-5/NOPB</a>	Obsolete	Production	SOIC (D)   8	-	-	Call TI	Call TI	-55 to 150	LM74 CIM5
LM74CIMX-3	NRND	Production	SOIC (D)   8	2500   LARGE T&R	No	SNPB	Level-1-235C-UNLIM	-55 to 150	LM74 CIM3
LM74CIMX-3.A	NRND	Production	SOIC (D)   8	2500   LARGE T&R	No	SNPB	Level-1-235C-UNLIM	-55 to 150	LM74 CIM3
<a href="#">LM74CIMX-3/NOPB</a>	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-55 to 150	LM74 CIM3
LM74CIMX-3/NOPB.A	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-55 to 150	LM74 CIM3
<a href="#">LM74CIMX-5/NOPB</a>	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-55 to 150	LM74 CIM5
LM74CIMX-5/NOPB.A	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-55 to 150	LM74 CIM5
<a href="#">LM74CITP-3/NOPB</a>	Obsolete	Production	DSBGA (YTA)   5	-	-	Call TI	Call TI	-40 to 125	10
<a href="#">LM74CITPX-3/NOPB</a>	Active	Production	DSBGA (YTA)   5	3000   LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	10
LM74CITPX-3/NOPB.A	Active	Production	DSBGA (YTA)   5	3000   LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	10

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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## TAPE AND REEL INFORMATION



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM74CIMX-3/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LM74CIMX-5/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LM74CITPX-3/NOPB	DSBGA	YTA	5	3000	178.0	8.4	1.7	1.7	0.76	4.0	8.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

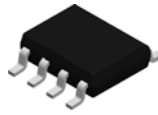
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM74CIMX-3/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LM74CIMX-5/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LM74CITPX-3/NOPB	DSBGA	YTA	5	3000	208.0	191.0	35.0

## TUBE



\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
LM74CIM-3	D	SOIC	8	95	495	8	4064	3.05
LM74CIM-3	D	SOIC	8	95	495	8	4064	3.05
LM74CIM-5	D	SOIC	8	95	495	8	4064	3.05
LM74CIM-5	D	SOIC	8	95	495	8	4064	3.05
LM74CIM-5.A	D	SOIC	8	95	495	8	4064	3.05
LM74CIM-5.A	D	SOIC	8	95	495	8	4064	3.05

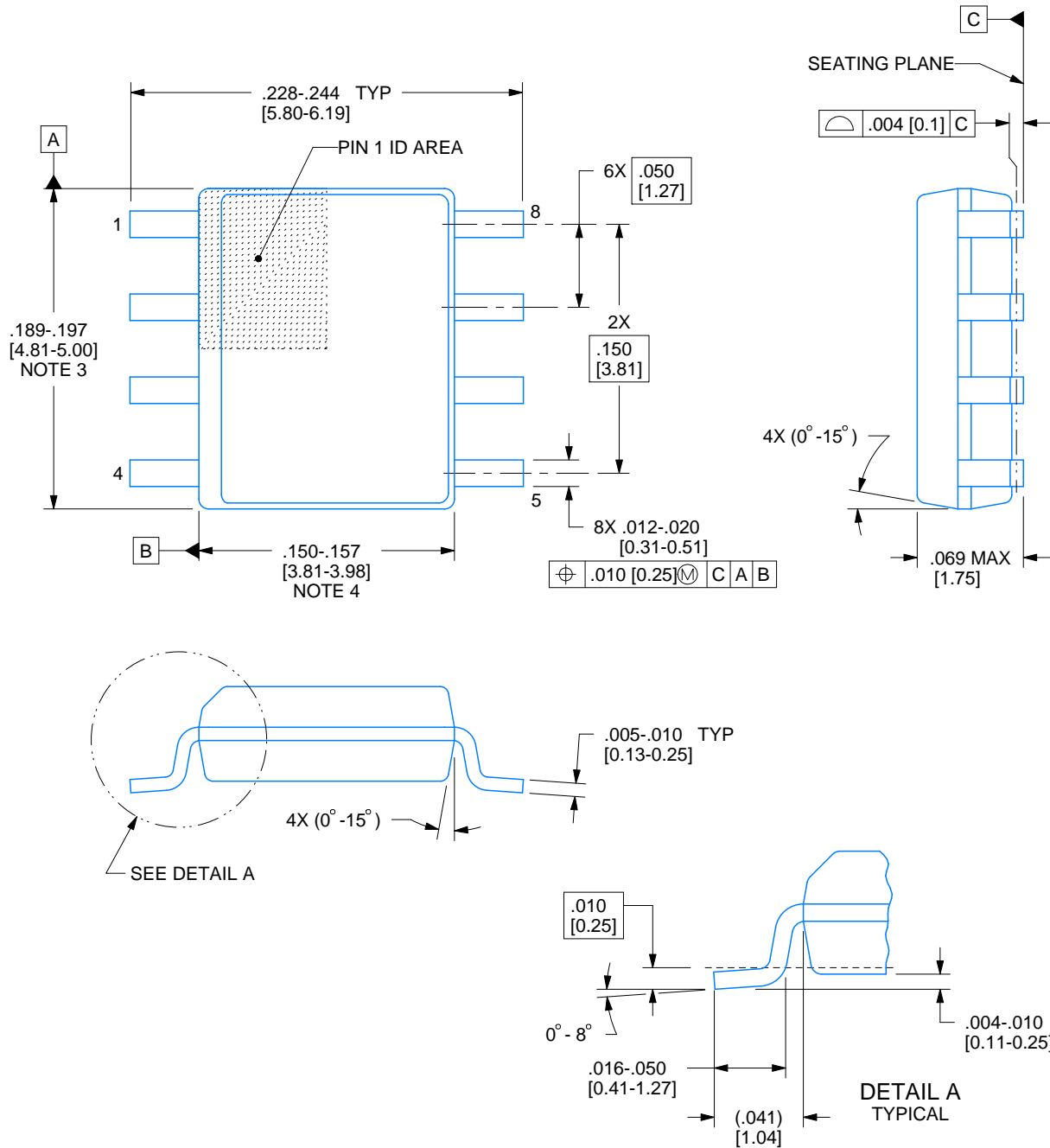


**D0008A**

# PACKAGE OUTLINE

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

## NOTES:

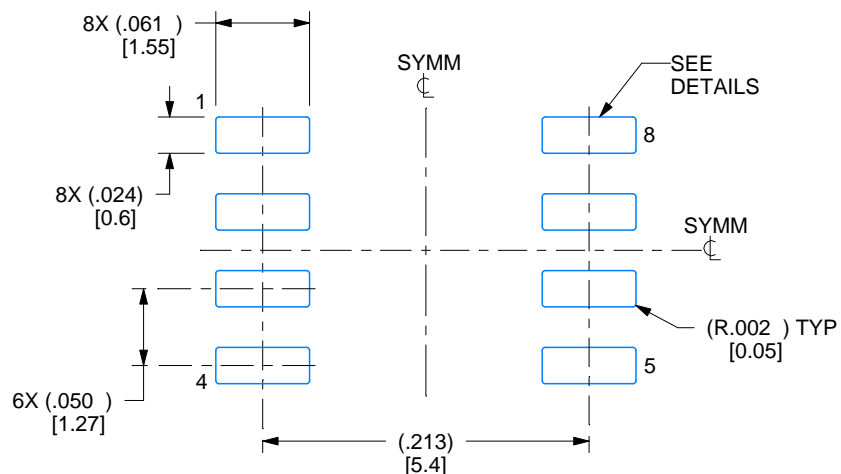
1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

# EXAMPLE BOARD LAYOUT

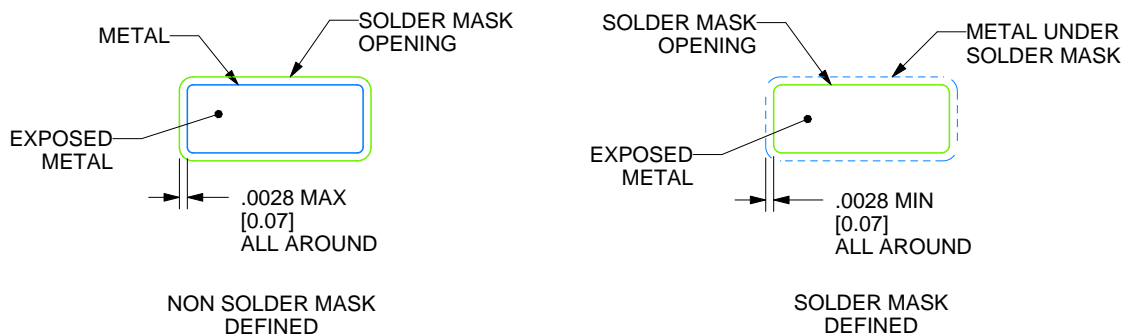
D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

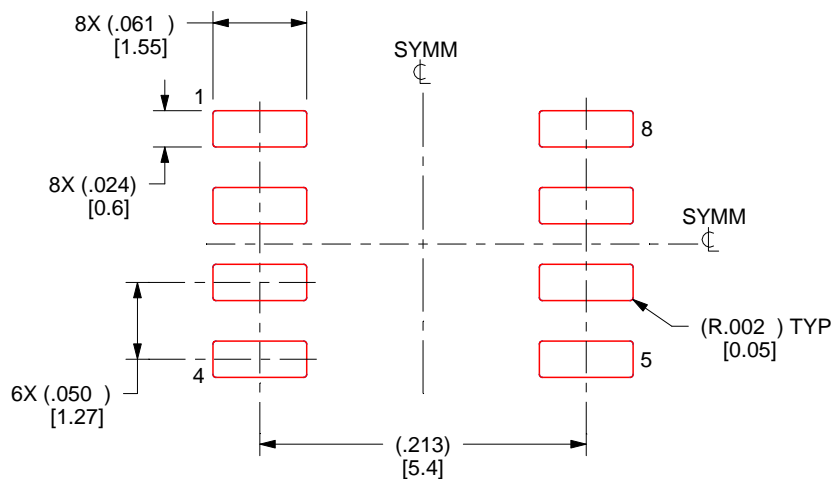
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



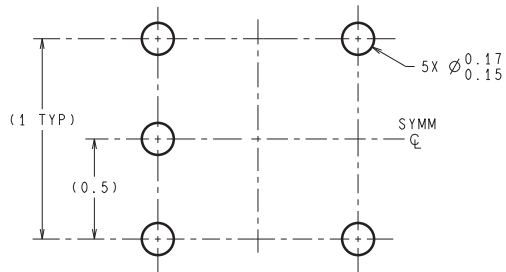
SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

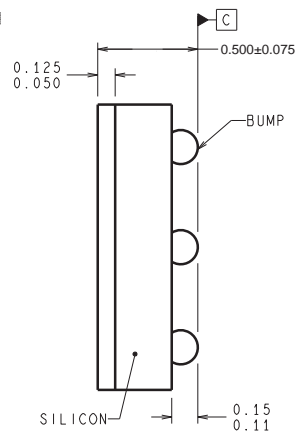
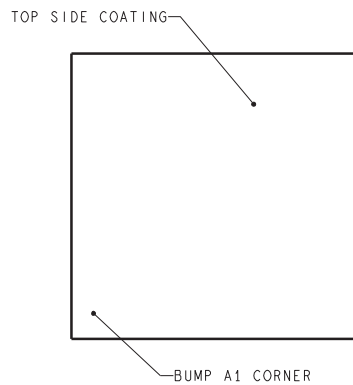
NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

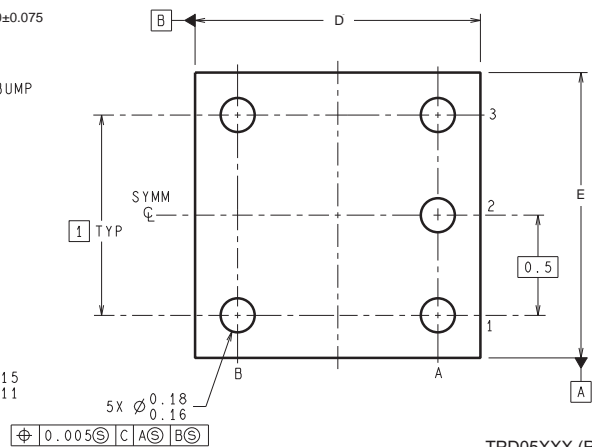
YTA0005



## LAND PATTERN RECOMMENDATION



DIMENSIONS ARE IN MILLIMETERS  
DIMENSIONS IN ( ) FOR REFERENCE ONLY



TPD05XXX (Rev A)

D: Max = 1.667 mm, Min = 1.606 mm

E: Max = 1.616 mm, Min = 1.555 mm

4215103/A 12/12

NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.  
B. This drawing is subject to change without notice.

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Last updated 10/2025