

LM71/LM71-Q1 SPI/MICROWIRE 13 位加号温度传感器

1 特性

- LM71Q 符合 AEC-Q100 0 级标准并且采用汽车级工艺流程制造
- 5 引脚 SOT-23 封装或 6 引脚无后拉 WSON 封装
- 在 -40°C 至 $+150^{\circ}\text{C}$ 整个温度范围内正常工作
- SPI 和 MICROWIRE 总线接口
- 主要规格：
 - 电源电压：2.65V 至 5.5V
 - 电源电流
 - 工作电流：300 μA （典型值）
 - 550 μA （最大值）
 - 温度精度
 - -10°C 至 $+65^{\circ}\text{C}$ ： $\pm 1.5^{\circ}\text{C}$ （最大值）
 - -40°C 至 150°C ： $+3/-2^{\circ}\text{C}$ （最大值）
 - 温度分辨率：31.25m $^{\circ}\text{C}$

2 应用

- 系统热管理
- 个人计算机
- 便携式电子设备
- 磁盘驱动器
- 办公电子设备
- 电子测试设备
- 自动售货机
- 汽车

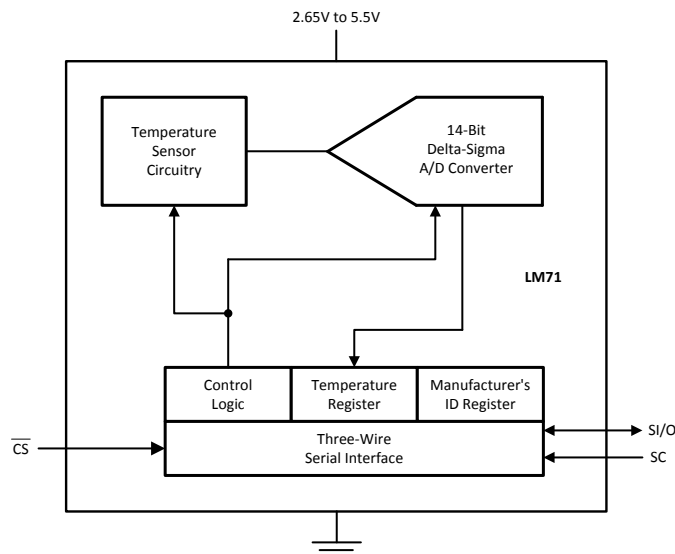
3 说明

LM71 是一款低功耗、高分辨率数字温度传感器，具有 SPI 和 MICROWIRE 兼容接口，采用 5 引脚 SOT-23 或 6 引脚 WSON（无后拉）封装。主机可随时查询 LM71 以读取温度。其低工作电流在低功耗至关重要的系统中很有用。

LM71 具有 13 位加号温度分辨率（每 LSB 0.03125 $^{\circ}\text{C}$ ），工作温度范围为 -40°C 至 $+150^{\circ}\text{C}$ 。

LM71 的 2.65V 至 5.5V 电源电压范围、快速转换速率、低电源电流和简单 SPI 接口使其成为各种应用的理想之选。LM71Q 仅采用 5 引线 SOT-23 封装。

简化方框图



3.1 Connection Diagram

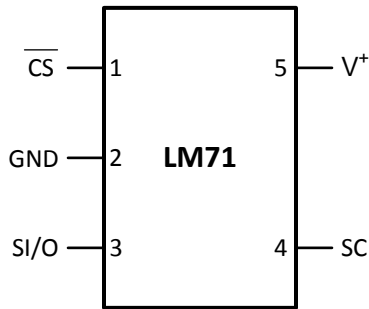


Figure 1. 5-Pin SOT-23
See Package Number DBV

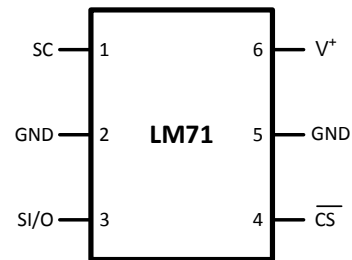


Figure 2. 6-Pin WSON No Pull-Back
See Package Number NGG0006A

Table 1. PIN DESCRIPTIONS

Label	Pin Number		Function	Typical Connection
	SOT-23-5	WSON-6		
$\overline{\text{CS}}$	1	4	Chip Select input	From controller
GND	2	2, 5	Power Supply Ground	Connect all GND Pins to ground
SI/O	3	3	Slave Input/Output - Serial bus bi-directional data line. Schmitt trigger input.	From and to controller
SC	4	1	Slave Clock - Serial bus clock Schmitt trigger input line	From controller
V ⁺	5	6	Positive Supply Voltage Input	DC voltage from 2.65V to 5.5V. Bypass with a 0.1 μF ceramic capacitor.

3.2 Typical Application

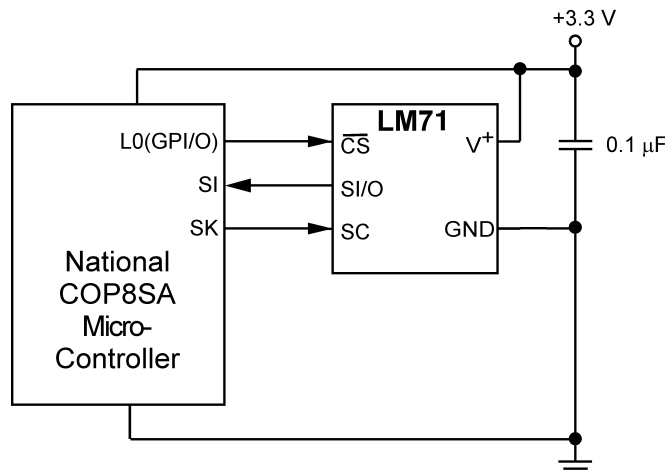


Figure 3. COP Microcontroller Interface

3.1 Electrostatic Discharge Caution



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.

3.2 Trademarks

All trademarks are the property of their respective owners.

4 Absolute Maximum Ratings⁽¹⁾

Supply Voltage		-0.3V to 6.0V
Voltage at any Pin		-0.3V to V^+ + 0.3V
Input Current at any Pin ⁽²⁾		5 mA
Storage Temperature		-65°C to +150°C
Soldering Information, Lead Temperature	SOT-23-5 Package	Vapor Phase (60 seconds) 215°C
		Infrared (15 seconds) 220°C
	WSON-6 Package	Infrared (5 seconds) 215°C
ESD Susceptibility ⁽³⁾	Human Body Model	2000V
	Machine Model	200V

(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.

(3) Human body model, 100 pF discharged through a 1.5 k Ω resistor. Machine model, 200 pF discharged directly into each pin.

5 Operating Ratings

Specified Temperature Range ⁽¹⁾ (T_{MIN} to T_{MAX})	LM71CIMF, LM71CISD, LM71QCIMF	-40°C to +150°C
Supply Voltage Range (+ V_S)	LM71CIMF, LM71CISD, LM71QCIMF	+2.65V to +5.5V

(1) The life expectancy of the LM71 will be reduced when operating at elevated temperatures. LM71 θ_{JA} (thermal resistance, junction-to-ambient) when attached to a printed circuit board with 2 oz. foil is summarized in the table below:

Device Number	Thermal Resistance (θ_{JA})
LM71CIMF/LM71QCIMF	250°C/W
LM71CISD	57.6°C/W

6 Temperature-to-Digital Converter Characteristics

Unless otherwise noted, these specifications apply for $V^+ = 2.65V$ to $3.6V^{(1)}$. **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 noted.

Parameter	Conditions	Typical ⁽²⁾	LM71CIMF LM71CISD Limits ⁽³⁾	Units (Limit)
Temperature Error ⁽¹⁾⁽⁴⁾	$T_A = -10^\circ C$ to $+65^\circ C$		± 1.5	$^\circ C$ (max)
	$T_A = -40^\circ C$ to $+85^\circ C$		± 2.0	$^\circ C$ (max)
	$T_A = -40^\circ C$ to $+150^\circ C$		$+3/-2$	$^\circ C$ (max)
Resolution		14 0.03125		Bits $^\circ C$
Temperature Conversion Time	See ⁽⁵⁾	200	270	ms (max)
Quiescent Current	Serial Bus Inactive	300	550	μA (max)

- (1) The LM71 will operate properly over the V^+ supply voltage range of 2.65V to 5.5V.
- (2) Typicals are at $T_A = 25^\circ C$ and represent most likely parametric norm.
- (3) Limits are ensured to AOQL (Average Outgoing Quality Level).
- (4) For best accuracy, minimize output loading. Higher sink currents can affect sensor accuracy with internal heating. This can cause an error of $0.64^\circ C$ at full rated sink current and saturation voltage based on junction-to-ambient thermal resistance.
- (5) Following a power on reset, the user must allow at least 270 ms before making the first read transaction to ensure a first valid temperature read. After the first read, in order to ensure an accurate temperature result, the time interval between any two consecutive temperature reads must be greater than the maximum conversion time of 270 ms. For more information, refer to [SNLA296](#).

7 Logic Electrical Characteristics

DIGITAL DC CHARACTERISTICS

Unless otherwise noted, these specifications apply for $V^+ = 2.65V$ to $3.6V^{(1)}$. **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 noted.

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

- (1) The LM71 will operate properly over the V^+ supply voltage range of 2.65V to 5.5V.
- (2) Typicals are at $T_A = 25^\circ C$ and represent most likely parametric norm.
- (3) Limits are ensured to AOQL (Average Outgoing Quality Level).

SERIAL BUS DIGITAL SWITCHING CHARACTERISTICS

Unless otherwise noted, these specifications apply for $V^+ = 2.65V$ to $3.6V^{(1)}$; C_L (load capacitance) on output lines = 100 pF 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 noted.

Symbol	Parameter	Conditions	Typical ⁽²⁾	Limits ⁽³⁾	Units (Limit)
t_1	SC (Clock) Period			0.16 DC	μs (min) (max)
t_2	\overline{CS} Low to SC (Clock) High Set-Up Time			100	ns (min)
t_3	\overline{CS} Low to Data Out (SO) Delay			70	ns (max)
t_4	SC (Clock) Low to Data Out (SO) Delay			70	ns (max)
t_5	\overline{CS} High to Data Out (SO) TRI-STATE			200	ns (max)
t_6	SC (Clock) High to Data In (SI) Hold Time			50	ns (min)
t_7	Data In (SI) Set-Up Time to SC (Clock) High			30	ns (min)
t_r	SC (Clock) Rise Time			100	ns (max)
t_f	SC (Clock) Fall Time			100	ns (max)

- (1) The LM71 will operate properly over the V^+ supply voltage range of 2.65V to 5.5V.
- (2) Typicals are at $T_A = 25^\circ C$ and represent most likely parametric norm.
- (3) Limits are ensured to AOQL (Average Outgoing Quality Level).

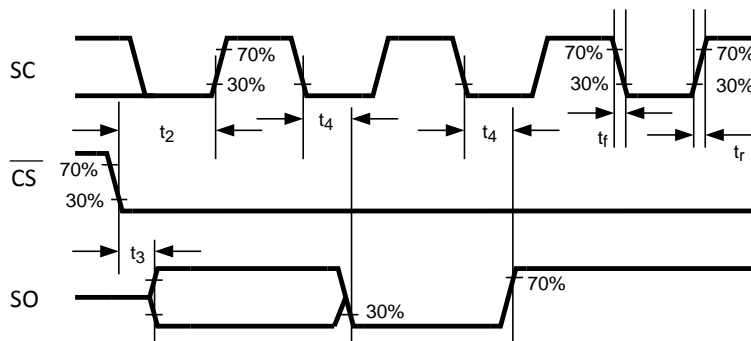


Figure 4. Data Output Timing Diagram

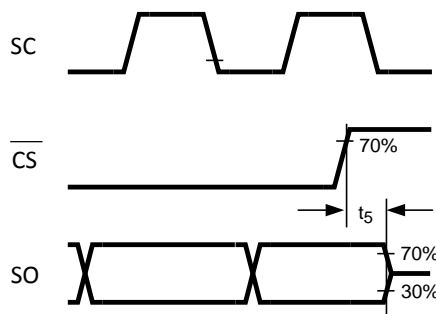


Figure 5. TRI-STATE Data Output Timing Diagram

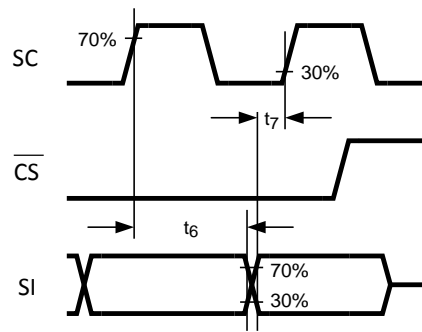


Figure 6. Data Input Timing Diagram

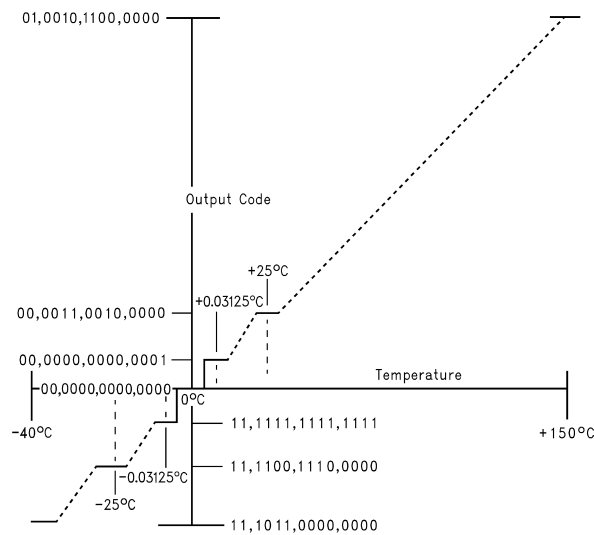


Figure 7. Temperature-to-Digital Transfer Function (Non-linear scale for clarity)

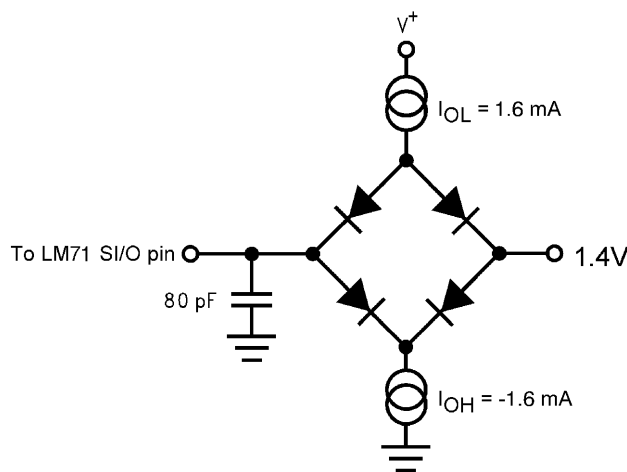
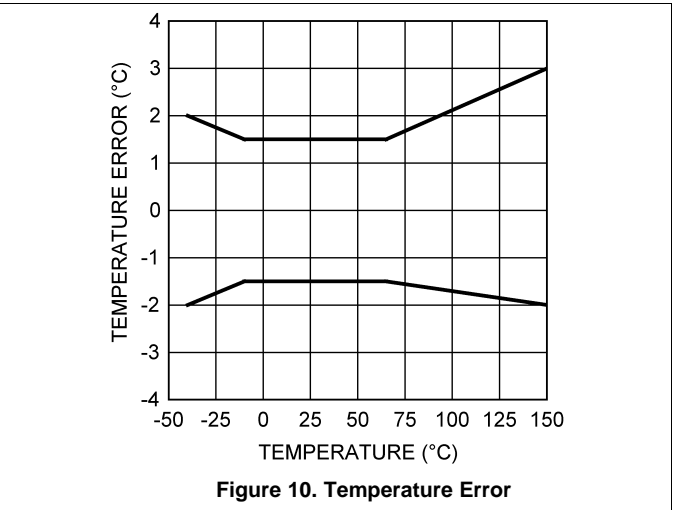
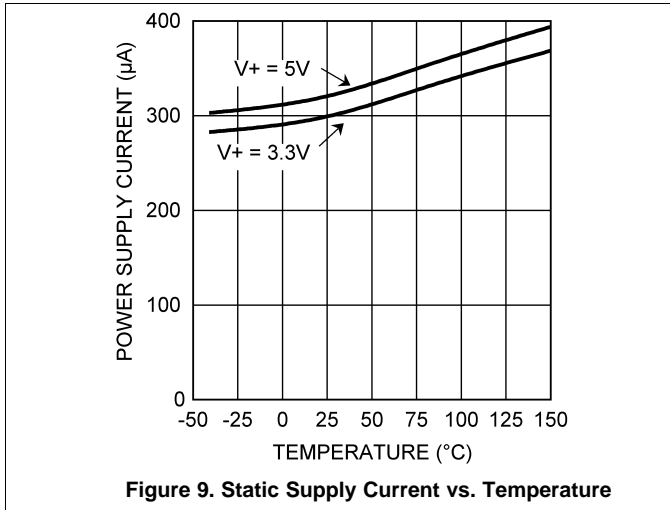


Figure 8. TRI-STATE Test Circuit

8 Typical Performance Characteristics



9 Functional Description

The LM71 temperature sensor incorporates a temperature sensor and 13-bit plus sign $\Delta\Sigma$ ADC (Delta-Sigma Analog-to-Digital Converter). Compatibility of the LM71'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 LM71 as TI product.

9.1 POWER UP AND POWER DOWN

The LM71 always powers up in a known state. The power up default condition is continuous conversion mode. Immediately after power up the LM71 will output an erroneous code until the first temperature conversion has completed.

When the supply voltage is less than about 1.6V (typical), the LM71 is considered powered down. As the supply voltage rises above the nominal 1.6V power up threshold, the internal registers are reset to the power up default state described above.

9.2 SERIAL BUS INTERFACE

The LM71 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. \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 LM71 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 LM71 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. All zeros must be shifted in order to place the LM71 into continuous conversion mode. Only the following codes should be transmitted to the LM71:

- 00 hex for continuous conversion
- FF hex for shutdown

Another code may place the part into a test mode. Test modes are used by TI to thoroughly test the function of the LM71 during production testing. Only eight bits have been defined above since only the last eight transmitted are detected by the LM71, before \overline{CS} is taken HIGH.

The following communication can be used to determine the Manufacture'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 Manufacture's/Device ID data
- Write 8 to 16 bits of data commanding Conversion Mode
- Take \overline{CS} HIGH.

Note that 300 ms will have to pass for a conversion to complete before the LM71 actually transmits temperature data.

9.3 TEMPERATURE DATA FORMAT

Temperature data is represented by a 14-bit, two's complement word with an LSB (Least Significant Bit) equal to 0.03125°C:

Temperature	Digital Output	
	Binary	Hex
+150°C	0100 1011 0000 0011	4B03
+125°C	0011 1110 1000 0011	3E83
+25°C	0000 1100 1000 0011	0C83
+0.03125°C	0000 0000 0000 0111	0007
0°C	0000 0000 0000 0011	0003
-0.03125°C	1111 1111 1111 1111	FFFF
-25°C	1111 0011 1000 0011	F383
-40°C	1110 1100 0000 0011	EC03

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.

9.4 SHUTDOWN MODE/MANUFACTURER'S ID

Shutdown mode is enabled by writing XX FF to the LM71 as shown in [Figure 13](#). The serial bus is still active when the LM71 is in shutdown. When in shutdown mode the LM71 always will output 1000 0000 0000 1111. This is the manufacturer's/Device ID information. The first 5-bits of the field (1000 0XXX) are reserved for manufacturer's ID.

9.5 INTERNAL REGISTER STRUCTURE

The LM71 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.

9.5.1 Configuration Register

(Selects shutdown or continuous conversion modes):

Table 2. (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 LM70 into a manufacturer's test mode, upon which the LM71 will stop responding as described. These test modes are to be used for TI production testing only. See [SERIAL BUS INTERFACE](#) for a complete discussion.

9.5.2 Temperature Register

Table 3. (Read Only):

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
MSB	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit1	LSB	1	1

D0–D1: Logic 1 will be output on SI/O.

D2–D15: Temperature Data. One LSB = 0.03125°C. Two's complement format.

9.5.3 Manufacturer/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	1	1	1	1

D0–D1: Logic 1 will be output on SI/O.

D2–D15: Manufacturer's/Device ID Data. This register is accessed whenever the LM71 is in shutdown mode.

9.6 Serial Bus Timing Diagrams

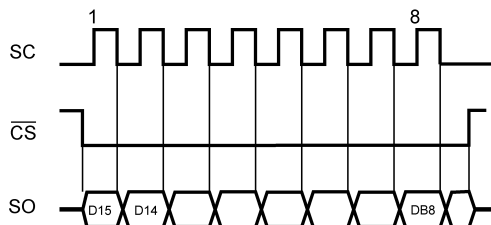


Figure 11. Reading Continuous Conversion - Single Eight-Bit Frame

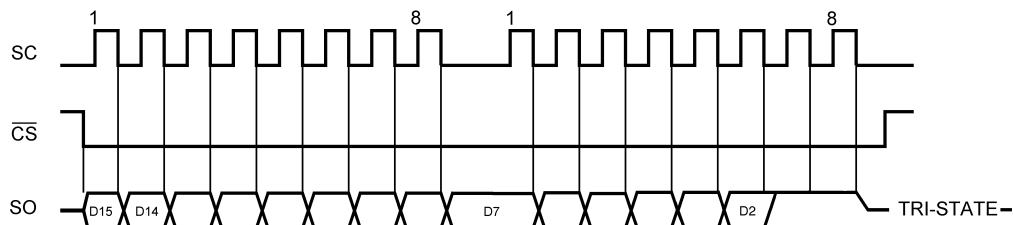


Figure 12. Reading Continuous Conversion - Two Eight-Bit Frames

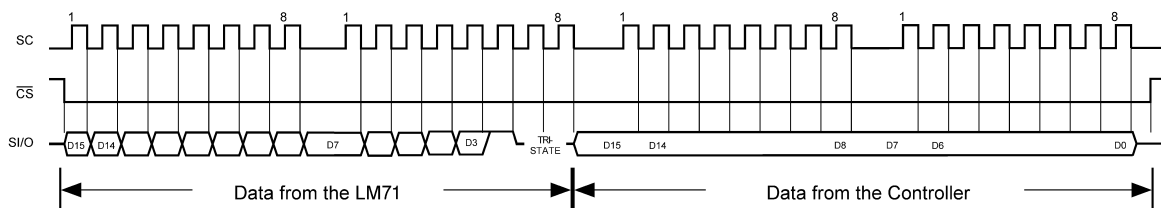


Figure 13. Writing Shutdown Control

9.7 Application Hints

To get the expected results when measuring temperature with an integrated circuit temperature sensor like the LM71, it is important to understand that the sensor measures its own die temperature. For the LM71, the best thermal path between the die and the outside world is through the LM71's pins. In the SOT-23 package, all the pins on the LM71 will have an equal effect on the die temperature. Because the pins represent a good thermal path to the LM71 die, the LM71 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 LM71 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 LM71 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 LM71 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 LM71 or its connections.

9.8 Typical Applications

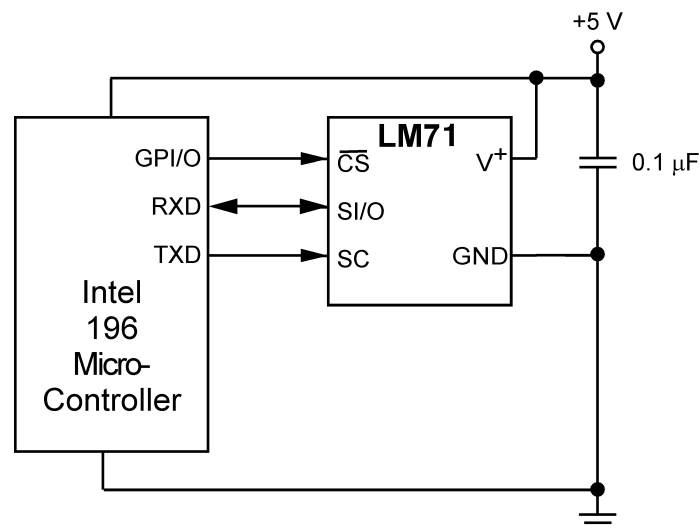


Figure 14. Temperature monitor using Intel 196 processor

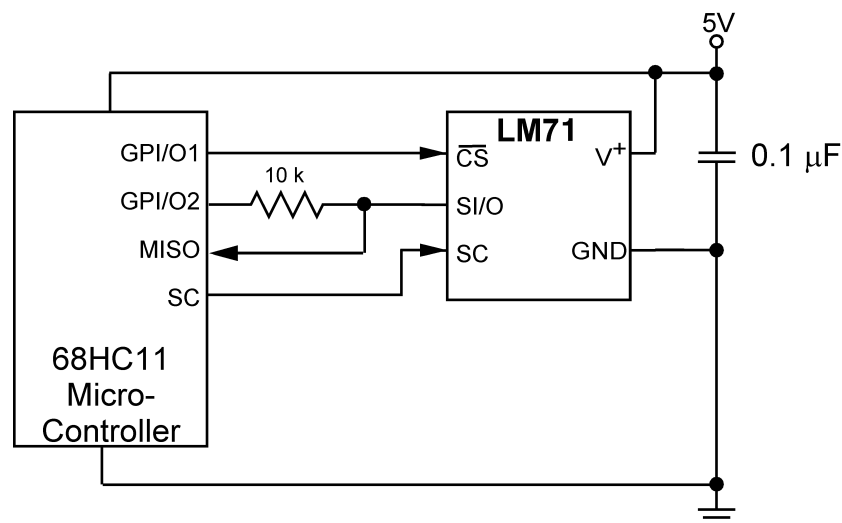


Figure 15. LM71 digital input control using micro-controller's general purpose I/O.

10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision D (March 2013) to Revision E	Page
---	-------------

- Added SNLA296 ulink to the temperature conversion time tablenote..... 4
-

Changes from Revision C (March 2013) to Revision D	Page
---	-------------

- Changed layout of National Semiconductor Data Sheet to TI format 11
-

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM71CIMF	NRND	SOT-23	DBV	5	1000	Non-RoHS & Green	Call TI	Level-1-260C-UNLIM		T16C	
LM71CIMF/NOPB	OBSOLETE	SOT-23	DBV	5		TBD	Call TI	Call TI		T16C	
LM71CIMFX/NOPB	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 150	T16C	Samples
LM71CISD/NOPB	ACTIVE	WSON	NGG	6	1000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 150	L71CI	Samples
LM71QCIMF/NOPB	OBSOLETE	SOT-23	DBV	5		TBD	Call TI	Call TI	-40 to 150	T16Q	
LM71QCIMFX/NOPB	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 150	T16Q	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF LM71, LM71-Q1 :

- Catalog : [LM71](#)
- Automotive : [LM71-Q1](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*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
LM71CIMF	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM71CIMFX/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM71CISD/NOPB	WSO	NGG	6	1000	178.0	12.4	3.3	3.3	1.0	8.0	12.0	Q1
LM71QCIMFX/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM71CIMF	SOT-23	DBV	5	1000	208.0	191.0	35.0
LM71CIMFX/NOPB	SOT-23	DBV	5	3000	208.0	191.0	35.0
LM71CISD/NOPB	WSON	NGG	6	1000	208.0	191.0	35.0
LM71QCIMFX/NOPB	SOT-23	DBV	5	3000	208.0	191.0	35.0

EXAMPLE BOARD LAYOUT

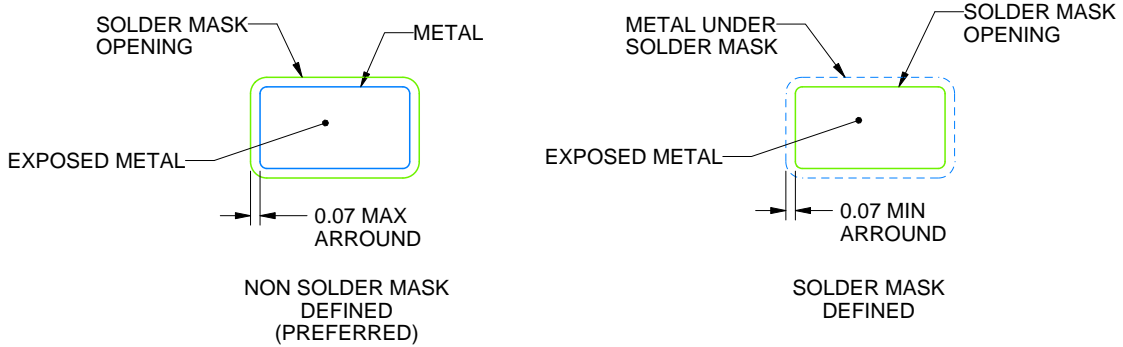
DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

4214839/K 08/2024

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

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4214839/K 08/2024

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.

重要声明和免责声明

TI“按原样”提供技术和可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证没有瑕疵且不做任何明示或暗示的担保，包括但不限于对适销性、某特定用途方面的适用性或不侵犯任何第三方知识产权的暗示担保。

这些资源可供使用 TI 产品进行设计的熟练开发人员使用。您将自行承担以下全部责任：(1) 针对您的应用选择合适的 TI 产品，(2) 设计、验证并测试您的应用，(3) 确保您的应用满足相应标准以及任何其他功能安全、信息安全、监管或其他要求。

这些资源如有变更，恕不另行通知。TI 授权您仅可将这些资源用于研发本资源所述的 TI 产品的应用。严禁对这些资源进行其他复制或展示。您无权使用任何其他 TI 知识产权或任何第三方知识产权。您应全额赔偿因在这些资源的使用中对 TI 及其代表造成的任何索赔、损害、成本、损失和债务，TI 对此概不负责。

TI 提供的产品受 [TI 的销售条款](#) 或 [ti.com](#) 上其他适用条款/TI 产品随附的其他适用条款的约束。TI 提供这些资源并不会扩展或以其他方式更改 TI 针对 TI 产品发布的适用的担保或担保免责声明。

TI 反对并拒绝您可能提出的任何其他或不同的条款。

邮寄地址：Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

Copyright © 2024，德州仪器 (TI) 公司