


LM70 SPI/MICROWIRE 10-Bit plus Sign Digital Temperature Sensor

Check for Samples: [LM70](#)

FEATURES

- 0.25°C Temperature Resolution.
- Shutdown Mode Conserves Power Between Temperature Reading
- SPI and MICROWIRE Bus Interface
- VSSOP-8 and WSON-8 Packages Save Space
- UL Recognized Component 

APPLICATIONS

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

KEY SPECIFICATIONS

- Supply Voltage 2.65V to 5.5V
- Supply Current
 - Operating
 - 260 μ A (typ)
 - 490 μ A (max)
 - Shutdown
 - 12 μ A (typ)
- Temperature Accuracy
 - -40°C to 85°C, $\pm 2^\circ$ C(max)
 - -10°C to 65°C, +1.5/-2°C(max)
 - -55°C to 125°C, +3/-2°C(max)
 - -55°C to 150°C, +3.5/-2°C(max)

DESCRIPTION

The LM70 is a temperature sensor, Delta-Sigma analog-to-digital converter with an SPI and MICROWIRE compatible interface available in WSON and VSSOP 8-pin packages. The host can query the LM70 at any time to read temperature. A shutdown mode decreases power consumption to less than 10 μ A. This mode is useful in systems where low average power consumption is critical.

The LM70 has 10-bit plus sign temperature resolution (0.25°C per LSB) while operating over a temperature range of -55°C to +150°C.

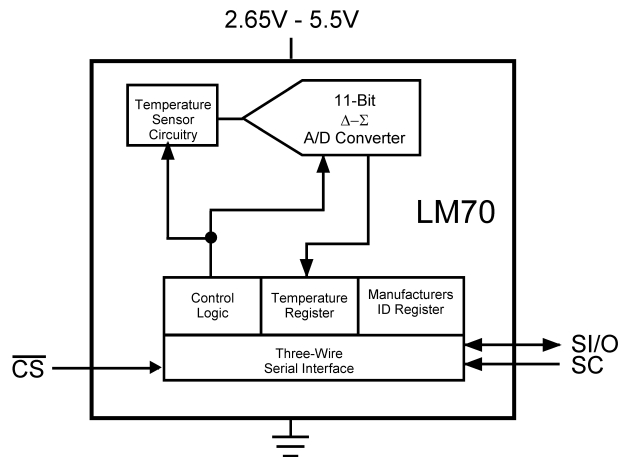
The LM70's 2.65V to 5.5V supply voltage range, low supply current and simple SPI interface make it ideal for a wide range of applications. These include thermal management and protection applications in hard disk drives, printers, electronic test equipment, and office electronics.



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Simplified Block Diagram



Connection Diagram

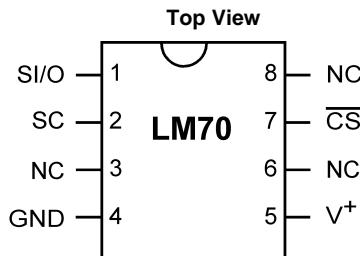


Figure 1. VSSOP-8 Package
See Package Number DGK0008A

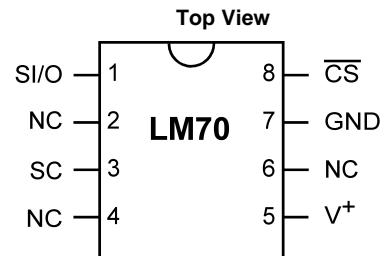


Figure 2. WSON-8 Package
See Package Number NGK0008A

PIN DESCRIPTIONS

| Pin Name | VSSOP-8 Pin No. | WSON-8 Pin No. | Description | Typical Connection |
|----------------|-----------------|----------------|--|--|
| S/I/O | 1 | 1 | Input/Output - Serial bus bi-directional data line. Schmitt trigger input. | From and to Controller |
| SC | 2 | 3 | Clock - Serial bus clock Schmitt trigger input line. | From Controller |
| GND | 4 | 7 | Power Supply Ground | Ground |
| V ⁺ | 5 | 5 | Positive Supply Voltage Input | DC Voltage from 2.65V to 5.5V. Bypass with a 0.1 μF ceramic capacitor. |
| CS-bar | 7 | 8 | Chip Select input. | From Controller |
| NC | 3, 6, 8 | 2, 4, 6 | No Connect | These pins are not connected to the LM70 die in any way. |

Typical Application

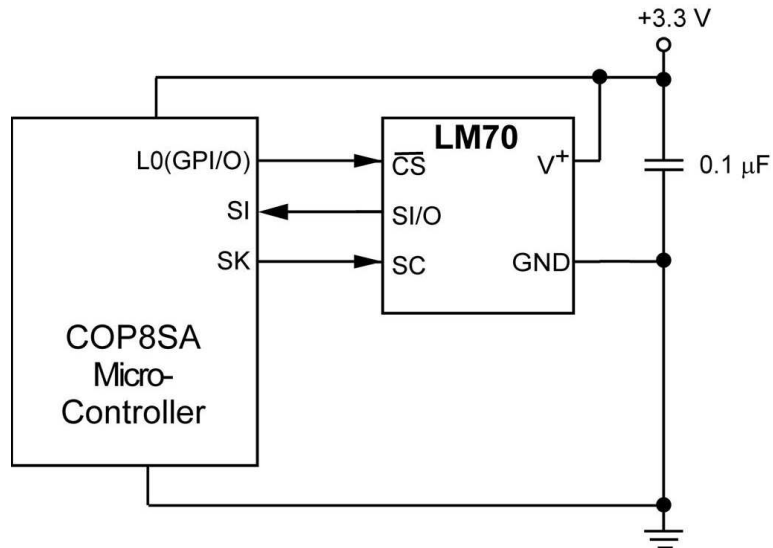


Figure 3. COP Microcontroller Interface



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⁽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 |
| Package Input Current ⁽²⁾ | 20 mA |
| Storage Temperature | -65°C to +150°C |
| Soldering Information, Lead Temperature | |
| VSSOP-8 and WSON-8 Packages ⁽³⁾ | 215°C 220°C |
| Vapor Phase (60 seconds) | |
| Infrared (15 seconds) | |
| ESD Susceptibility ⁽⁴⁾ | |
| Human Body Model | 3000V |
| Machine Model | 300V |

- (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 < 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) See the section titled "Surface Mount" found in a current Linear Data Book for other methods of soldering surface mount devices.
- (4) Human body model, 100 pF discharged through a 1.5 kΩ resistor. Machine model, 200 pF discharged directly into each pin.

Operating Ratings

| | |
|---|--------------------------------------|
| Specified Temperature Range | T _{MIN} to T _{MAX} |
| See ⁽¹⁾ | -55°C to +150°C |
| Supply Voltage Range (+V _S) | +2.65V to +5.5V |

- (1) The life expectancy of the LM70 will be reduced when operating at elevated temperatures. LM70 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 LM70CILD Thermal Resistance (θ_{JA}), 51.3°C/W, Device Number LM70C1MM Thermal Resistance (θ_{JA}), 200°C/W

Temperature-to-Digital Converter Characteristics

Unless otherwise noted, these specifications apply for V⁺ = 2.65V to 3.6V for the LM70-3 and V⁺ = 4.5V to 5.5V for the LM70-5⁽¹⁾. **Boldface limits apply for T_A = T_J = T_{MIN} to T_{MAX}**; all other limits T_A = T_J = +25°C, unless otherwise noted.

| Parameter | Test Conditions | Typical ⁽²⁾ | LM70-5 Limits ⁽³⁾ | LM70-3 Limits ⁽³⁾ | Units (Limit) |
|----------------------------------|----------------------------------|------------------------|------------------------------|------------------------------|---------------|
| Temperature Error ⁽¹⁾ | T _A = -10°C to +65°C | | +1.5/-2.0 | +1.5/-2.0 | °C (max) |
| | T _A = -40°C to +85°C | | ±2.0 | ±2.0 | °C (max) |
| | T _A = -55°C to +125°C | | +3.0/-2.0 | +3.0/-2.0 | °C (max) |
| | T _A = -55°C to +150°C | | +3.5/-2.0 | +3.5/-2.0 | °C (max) |
| Resolution | | 11 0.25 | | | Bits °C |
| Temperature Conversion Time | See ⁽⁴⁾ | 140 | 210 | 210 | ms (max) |
| Quiescent Current | Serial Bus Inactive | 260 | 490 | 490 | μA (max) |
| | Serial Bus Active | 260 | | | μA |
| | Shutdown Mode | 12 | | | μA |

- (1) Both part numbers of the LM70 will operate properly over the V⁺ supply voltage range of 2.65V to 5.5V. The temperature error for temperature ranges of -10°C to +65°C, -40°C to +85°C, -55°C to +125°C and -55°C to +150°C include error induced by power supply variation of ±5% from the nominal value. Temperature error will increase by ±0.3°C for a power supply voltage (V⁺) variation of ±10% from the nominal value.
- (2) Typicals are at T_A = 25°C and represent most likely parametric norm.
- (3) Limits are guaranteed to AOQL (Average Outgoing Quality Level).
- (4) This specification is provided only to indicate how often temperature data is updated. The LM70 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 3.6V for the LM70-3 and $V^+ = 4.5\text{V}$ to 5.5V for the LM70-5. **Boldface limits apply for $T_A = T_J = T_{\text{MIN}}$ to T_{MAX}** ; all other limits $T_A = T_J = +25^\circ\text{C}$, unless otherwise noted.

| Parameter | | Test Conditions | Typical ⁽¹⁾ | Limits ⁽²⁾ | 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 | $V^+ = 2.65\text{V}$ to 3.6V | 0.8 | 0.27 | V (min) |
| | | $V^+ = 4.5\text{V}$ to 5.5V | 0.8 | 0.35 | V (min) |
| $I_{\text{IN}(1)}$ | Logical "1" Input Current | $V_{\text{IN}} = V^+$ | 0.005 | 3.0 | μA (max) |
| $I_{\text{IN}(0)}$ | Logical "0" Input Current | $V_{\text{IN}} = 0\text{V}$ | -0.005 | -3.0 | μA (min) |
| C_{IN} | All Digital Inputs | | 20 | | pF |
| V_{OH} | High Level Output Voltage | $I_{\text{OH}} = -400 \mu\text{A}$ | | 2.4 | V (min) |
| V_{OL} | Low Level Output Voltage | $I_{\text{OL}} = +2 \text{mA}$ | | 0.4 | V (max) |
| $I_{\text{O_TRI-STATE}}$ | TRI-STATE Output Leakage Current | $V_{\text{O}} = \text{GND}$ $V_{\text{O}} = V^+$ | | -1 | μA (min) |
| | | | | +1 | μA (max) |

(1) Typicals are at $T_A = 25^\circ\text{C}$ and represent most likely parametric norm.

(2) Limits are guaranteed to AOQL (Average Outgoing Quality Level).

Logic Electrical Characteristics Serial Bus Digital Switching Characteristics

Unless otherwise noted, these specifications apply for $V^+ = 2.65\text{V}$ to 3.6V for the LM70-3 and $V^+ = 4.5\text{V}$ to 5.5V for the LM70-5. C_L (load capacitance) on output lines = 100pF unless otherwise specified. **Boldface limits apply for $T_A = T_J = T_{\text{MIN}}$ to T_{MAX}** ; all other limits $T_A = T_J = +25^\circ\text{C}$, unless otherwise noted.

| Parameter | | Test Conditions | Typical ⁽¹⁾ | Limits ⁽²⁾ | Units (Limit) |
|-----------|---|-----------------|------------------------|-----------------------|------------------------------|
| t_1 | SC (Clock) Period | | | 0.16 DC | μs (min) (max) |
| t_2 | $\overline{\text{CS}}$ Low to SC (Clock) High Set-Up Time | | | 100 | ns (min) |
| t_3 | $\overline{\text{CS}}$ Low to Data Out (SO) Delay | | | 70 | ns (max) |
| t_4 | SC (Clock) Low to Data Out (SO) Delay | | | 70 | ns (max) |
| t_5 | $\overline{\text{CS}}$ High to Data Out (SO) TRI-STATE | | | 200 | ns (min) |
| t_6 | SC (Clock) High to Data In (SI) Hold Time | | | 60 | ns (min) |
| t_7 | Data In (SI) Set-Up Time to SC (Clock) High | | | 30 | ns (min) |

(1) Typicals are at $T_A = 25^\circ\text{C}$ and represent most likely parametric norm.

(2) Limits are guaranteed to AOQL (Average Outgoing Quality Level).

Timing Diagrams

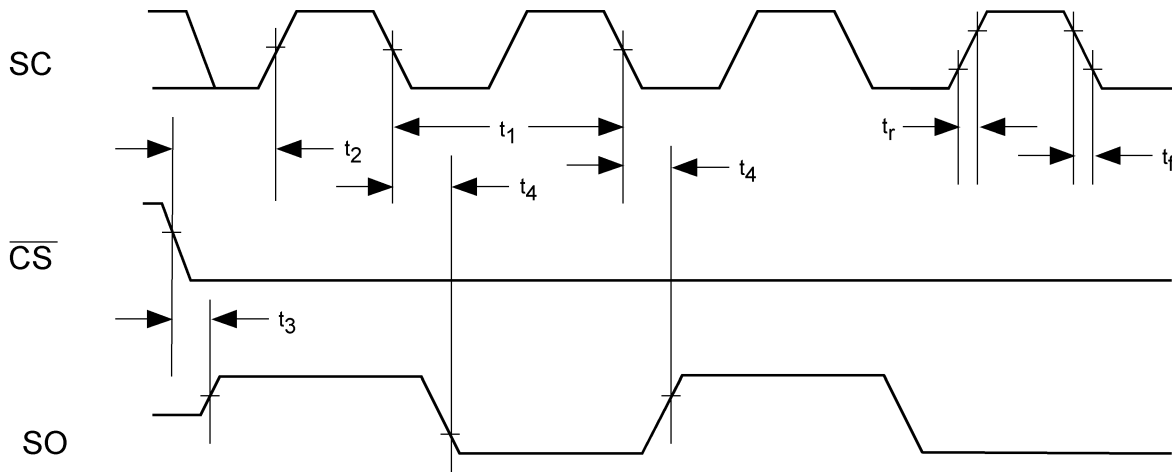


Figure 4. Data Output Timing Diagram

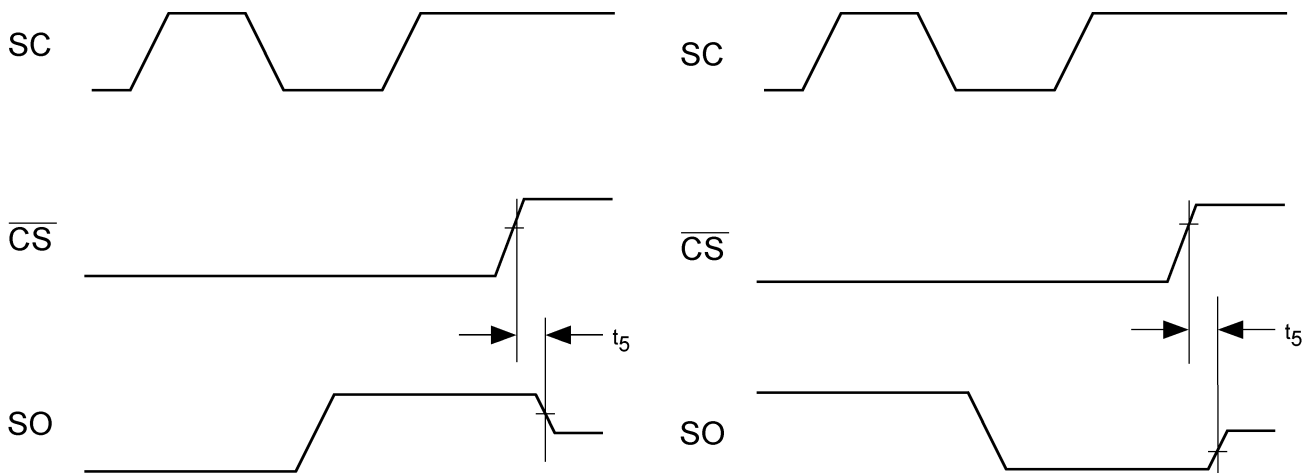


Figure 5. TRI-STATE Data Output Timing Diagram

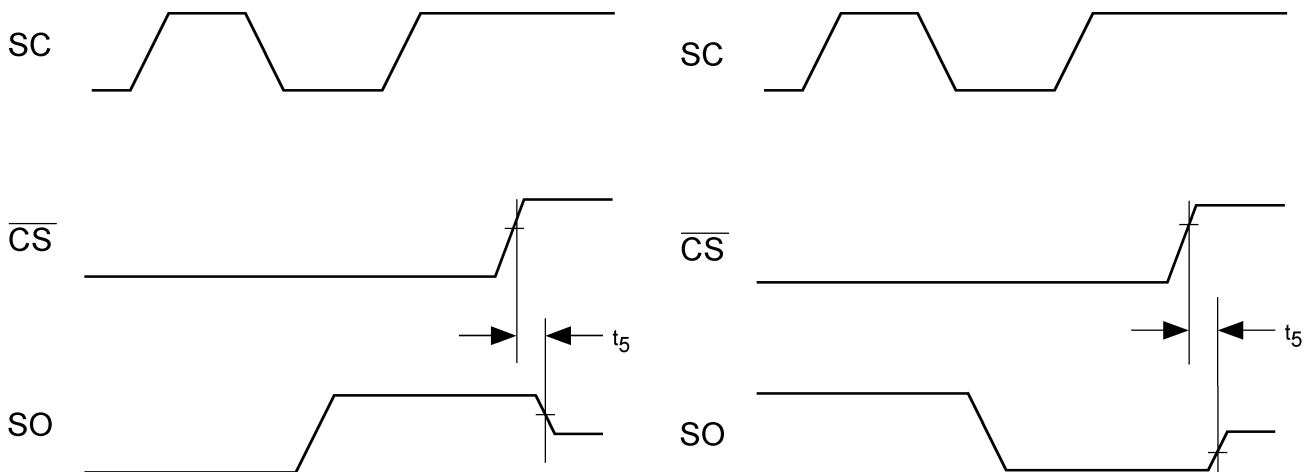


Figure 6. Data Input Timing Diagram

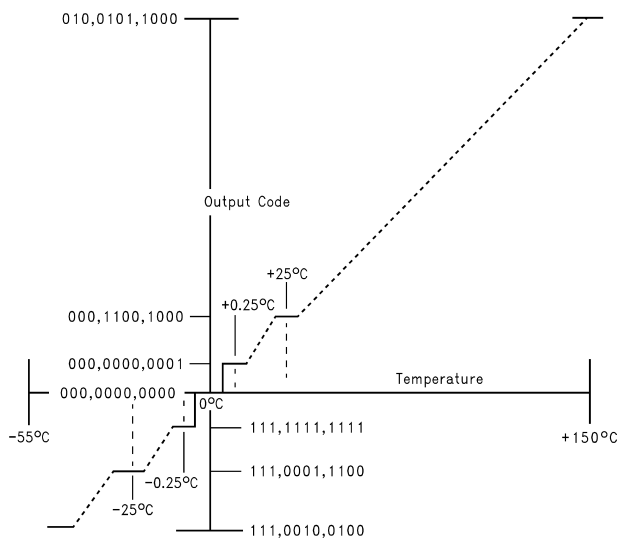


Figure 7. Temperature-to-Digital Transfer Function (Non-linear scale for clarity)

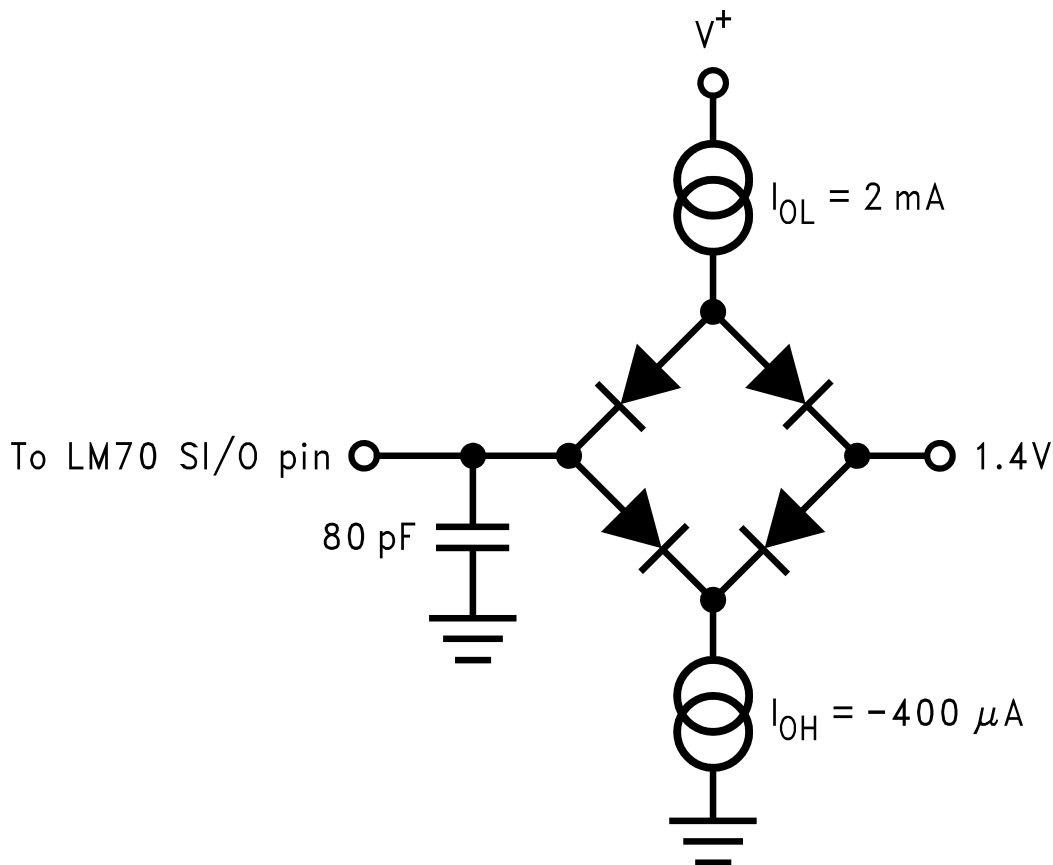


Figure 8. TRI-STATE Test Circuit

Typical Performance Characteristics

Average Power-On Reset Voltage vs Temperature

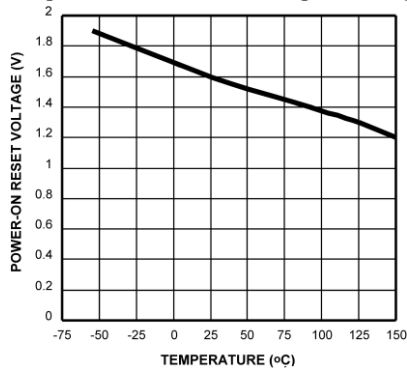


Figure 9.

Static Supply Current vs Temperature

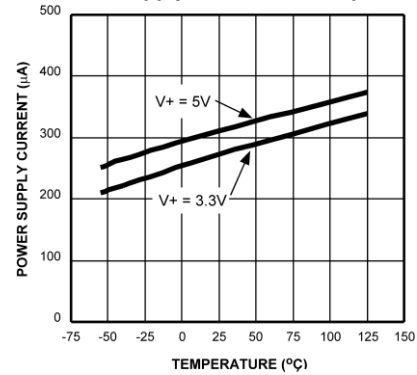


Figure 10.

Temperature Error

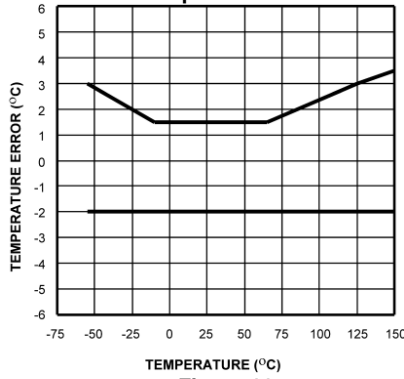


Figure 11.

FUNCTIONAL DESCRIPTION

The LM70 temperature sensor incorporates a band-gap type temperature sensor and 10-bit plus sign $\Delta\Sigma$ ADC (Delta-Sigma Analog-to-Digital Converter). Compatibility of the LM70'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 manufacturer's ID register identifies the LM70 as a TI product.

POWER UP AND POWER DOWN

The LM70 always powers up in a known state. The power up default condition is continuous conversion mode. Immediately after power up the LM70 will output an erroneous code until the first temperature conversion has completed.

When the supply voltage is less than about 1.6V (typical), the LM70 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.

SERIAL BUS INTERFACE

The LM70 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 TRISTATE. 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, ten temperature bits and 3 high bits) 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 LM70 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 LM70 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 LM70 out of shutdown. The following codes only should be transmitted to the LM70:

- 00 hex (normal operation)
- 01 hex (normal operation)
- 03 hex (normal operation)
- 07 hex (normal operation)
- 0F hex (normal operation)
- 1F hex (normal operation)
- 3F hex(normal operation)
- 7F hex(normal operation)
- FF hex (Shutdown, transmit manufacturer's ID)

any others may place the part into a Test Mode. Test Modes are used by TI to thoroughly test the function of the LM70 during production testing. Only eight bits have been defined above since only the last eight transmitted, before \overline{CS} is taken HIGH, are detected by the LM70

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

Note that 210 ms will have to pass for a conversion to complete before the LM70 actually transmits temperature data.

TEMPERATURE DATA FORMAT

Temperature data is represented by a 11-bit, two's complement word with an LSB (Least Significant Bit) equal to 0.25°C:

| Temperature | Digital Output | |
|-------------|---------------------|--------|
| | Binary | Hex |
| +150°C | 0100 1011 0001 1111 | 4B 1Fh |
| +125°C | 0011 1110 1001 1111 | 3E 9Fh |
| +25°C | 0000 1100 1001 1111 | 0B 9Fh |
| +0.25°C | 0000 0000 0011 1111 | 00 3Fh |
| 0°C | 0000 0000 0001 1111 | 00 1Fh |
| -0.25°C | 1111 1111 1111 1111 | FF FFh |
| -25°C | 1111 0011 1001 1111 | F3 9Fh |
| -55°C | 1110 0100 1001 1111 | E4 9Fh |

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 LM70 as shown in [Figure 14c](#). and discussed in Section 1.2. The serial bus is still active when the LM70 is in shutdown. Current draw drops to less than 10 μ A between serial communications. When in shutdown mode the LM70 always will output 1000 0001 0000 00XX. This is the manufacturer's ID/Device ID information. The first 5-bits of the field (1000 0XXX) are reserved for manufacturer's ID.

INTERNAL REGISTER STRUCTURE

The LM70 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 XX 00 hex enables continuous conversion mode.

Note: setting D0-D15 to any other values may place the LM70 into a manufacturer's test mode, upon which the LM70 will stop responding as described. These test modes are to be used for production testing only. See Section 1.2 Serial Bus Interface for a complete discussion.

TEMPERATURE REGISTER

Table 2. (Read Only):

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

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

D2–D4: Always set high.

D5–D15: Temperature Data. One LSB = 0.25°C. Two's complement format.

MANUFACTURER'S/DEVICE ID REGISTER

Table 3. (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 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | X | X |

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

D2–D4: Always set LOW.

D5–D15: Manufacturer's ID Data. This register is accessed whenever the LM70 is in shutdown mode.

Serial Bus Timing Diagrams

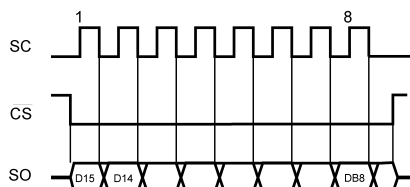


Figure 12. a) Reading Continuous Conversion - Single Eight-Bit Frame

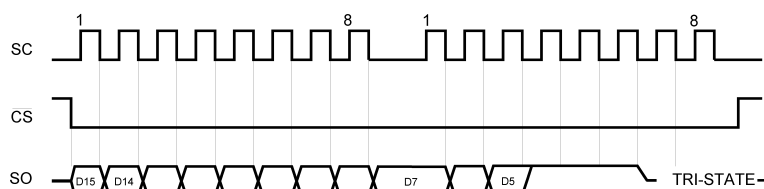


Figure 13. b) Reading Continuous Conversion - Two Eight-Bit Frames

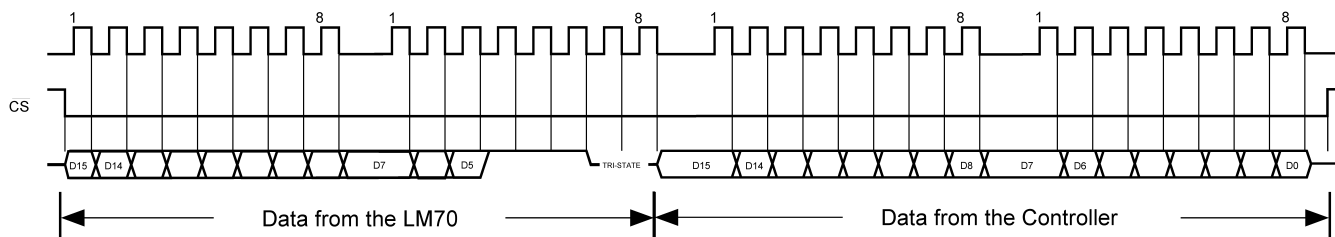


Figure 14. c) Writing Shutdown Control

Application Hints

To get the expected results when measuring temperature with an integrated circuit temperature sensor like the LM70, it is important to understand that the sensor measures its own die temperature. For the LM70, the best thermal path between the die and the outside world is through the LM70's pins. In the VSSOP-8 package the ground pin is connected to the back side of the LM70 die and thus has the most effect on the die temperature. Although the other pins will also have some effect on the LM70 die temperature and therefore should not be discounted. The LM70 will provide an accurate measurement of the temperature of the printed circuit board on which it is mounted, because the pins represent a good thermal path to the die. A less efficient thermal path exists between the plastic package and the LM70 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 LM70 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 LM70 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 LM70 or its connections.

Typical Applications

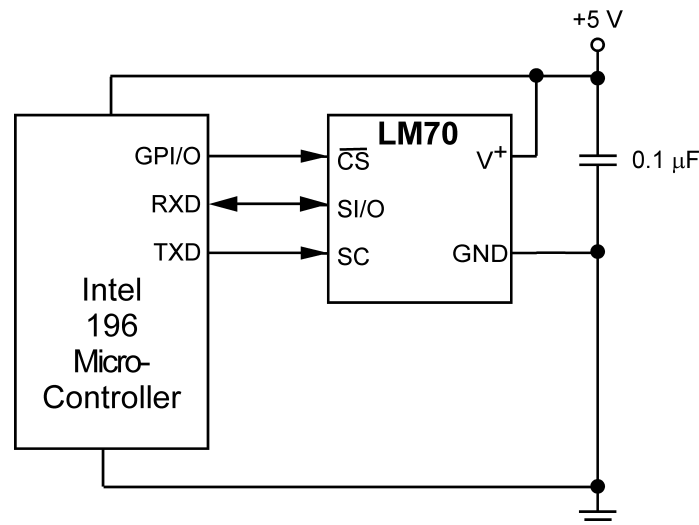


Figure 15. Temperature Monitor Using Intel 196 Processor

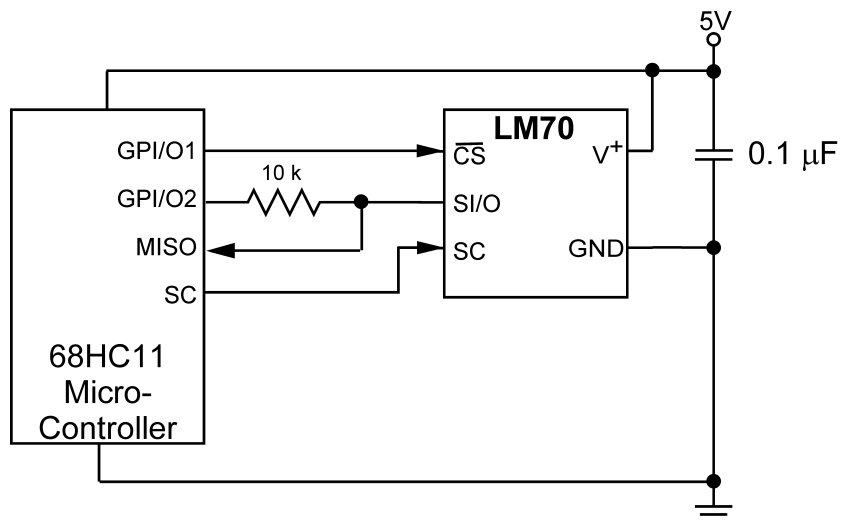


Figure 16. LM70 Digital Input Control Using Micro-Controller's General Purpose I/O

REVISION HISTORY

| Changes from Revision F (March 2013) to Revision G | Page |
|--|--------------------|
| • Changed layout of National Data Sheet to TI format | 13 |

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 |
|------------------|---------------|--------------|-----------------|------|-------------|------------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM70CILD-3/NOPB | ACTIVE | WSON | NGK | 8 | 1000 | RoHS & Green | SN | Level-3-260C-168 HR | -55 to 150 | T33 | Samples |
| LM70CILD-5/NOPB | ACTIVE | WSON | NGK | 8 | 1000 | RoHS & Green | SN | Level-3-260C-168 HR | -55 to 150 | T35 | Samples |
| LM70CILD-3/NOPB | ACTIVE | WSON | NGK | 8 | 4500 | RoHS & Green | SN | Level-3-260C-168 HR | -55 to 150 | T33 | Samples |
| LM70CIMM-3 | NRND | VSSOP | DGK | 8 | 1000 | Non-RoHS & Green | Call TI | Level-1-260C-UNLIM | -55 to 150 | T04C | |
| LM70CIMM-5 | NRND | VSSOP | DGK | 8 | 1000 | Non-RoHS & Green | Call TI | Level-1-260C-UNLIM | -55 to 150 | T03C | |
| LM70CIMM-5/NOPB | OBSOLETE | VSSOP | DGK | 8 | | TBD | Call TI | Call TI | -55 to 150 | T03C | |
| LM70CIMMX-3/NOPB | ACTIVE | VSSOP | DGK | 8 | 3500 | RoHS & Green | SN | Level-1-260C-UNLIM | -55 to 150 | T04C | Samples |
| LM70CIMMX-5/NOPB | ACTIVE | VSSOP | DGK | 8 | 3500 | RoHS & Green | SN | Level-1-260C-UNLIM | -55 to 150 | T03C | 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.

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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 |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM70CILD-3/NOPB | WSON | NGK | 8 | 1000 | 178.0 | 12.4 | 3.3 | 3.3 | 1.0 | 8.0 | 12.0 | Q1 |
| LM70CILD-5/NOPB | WSON | NGK | 8 | 1000 | 178.0 | 12.4 | 3.3 | 3.3 | 1.0 | 8.0 | 12.0 | Q1 |
| LM70CILD-3/NOPB | WSON | NGK | 8 | 4500 | 330.0 | 12.4 | 3.3 | 3.3 | 1.0 | 8.0 | 12.0 | Q1 |
| LM70CIMM-3 | VSSOP | DGK | 8 | 1000 | 178.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| LM70CIMM-5 | VSSOP | DGK | 8 | 1000 | 178.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| LM70CIMMX-3/NOPB | VSSOP | DGK | 8 | 3500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| LM70CIMMX-5/NOPB | VSSOP | DGK | 8 | 3500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM70CILD-3/NOPB | WSON | NGK | 8 | 1000 | 367.0 | 367.0 | 35.0 |
| LM70CILD-5/NOPB | WSON | NGK | 8 | 1000 | 367.0 | 367.0 | 35.0 |
| LM70CILD-3/NOPB | WSON | NGK | 8 | 4500 | 356.0 | 356.0 | 36.0 |
| LM70CIMM-3 | VSSOP | DGK | 8 | 1000 | 208.0 | 191.0 | 35.0 |
| LM70CIMM-5 | VSSOP | DGK | 8 | 1000 | 208.0 | 191.0 | 35.0 |
| LM70CIMMX-3/NOPB | VSSOP | DGK | 8 | 3500 | 367.0 | 367.0 | 35.0 |
| LM70CIMMX-5/NOPB | VSSOP | DGK | 8 | 3500 | 367.0 | 367.0 | 35.0 |

DGK0008A



PACKAGE OUTLINE

VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



NOTES:

PowerPAD is a trademark of Texas Instruments.

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. 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 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187.

EXAMPLE BOARD LAYOUT

DGK0008A

™ VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X



SOLDER MASK DETAILS

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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.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
9. Size of metal pad may vary due to creepage requirement.

EXAMPLE STENCIL DESIGN

DGK0008A

TM VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



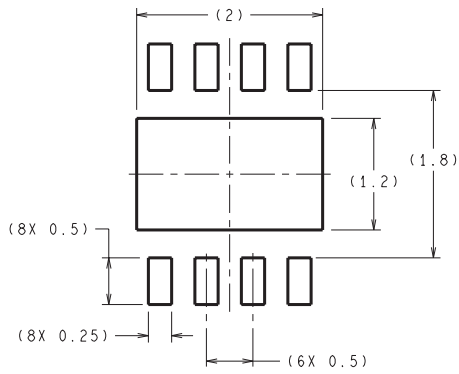
SOLDER PASTE EXAMPLE
SCALE: 15X

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NOTES: (continued)

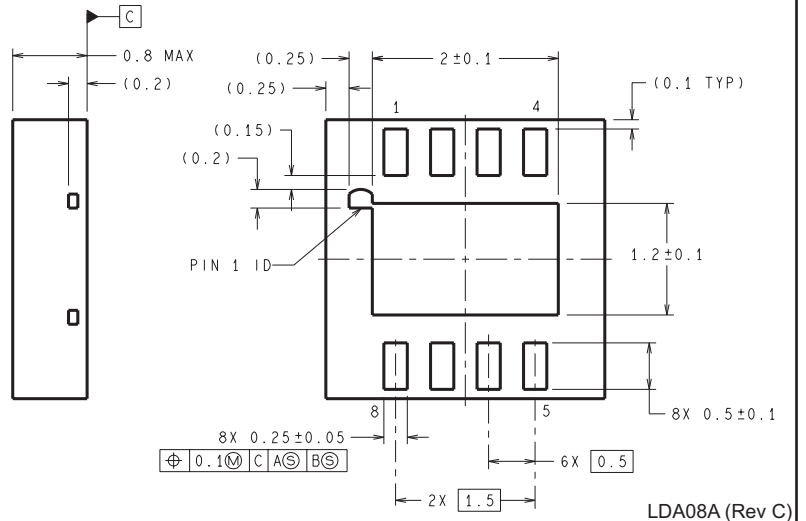
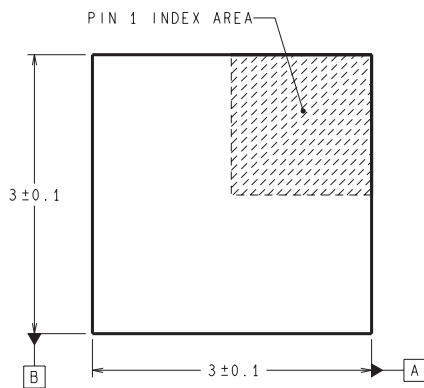
11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

NGK0008A



DIMENSIONS ARE IN MILLIMETERS

RECOMMENDED LAND PATTERN
1:1 RATIO WITH PKG SOLDER PADS



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