

## LM95172 13-Bit to 16-Bit 200°C Digital Temp Sensor with 3-Wire Interface

Check for Samples: [LM95172](#)

### FEATURES

- LM95172EWG is AEC-Q100 Grade 0 Qualified and is Manufactured on an Automotive Grade Flow.
- 13-Bit (0.0625°C LSB) to 16-Bit (0.0078125°C LSB) Temperature Resolution
- Wide -40°C to +200°C Temperature Range
- 35 ms Best Conversion Time Tracks Fast Temp Changes
- $\overline{\text{OVERTEMP}}$  Digital Output Switches when  $T_{\text{DIE}} > T_{\text{HIGH}}$
- Shutdown Mode Saves Power yet Wakes up for One-Shot Temperature Update
- SPI and MICROWIRE Bus Interface
- 10-Pin Cerpack High-Temperature Ceramic Package

### APPLICATIONS

- Automotive High Temperature Applications
- Industrial Power Controllers
- Industrial Motors, Gear Boxes
- Geothermal Instrumentation
- High Temperature Test Equipment

### KEY SPECIFICATIONS

- Analog and Digital Supply Voltage 3.0V to 5.5V
- Total Supply Current      Operating 400  $\mu\text{A}$  (typ)
  - Shutdown -40°C to +140°C 4  $\mu\text{A}$  (max)
  - Shutdown -40°C to +175°C 12  $\mu\text{A}$  (max)
  - Shutdown -40°C to +200°C 28  $\mu\text{A}$  (max)
- Temperature Accuracy
  - +175°C to +200°C  $\pm 3.0^\circ\text{C}$  (max)
  - +130°C to +160°C  $\pm 1.0^\circ\text{C}$  (max)
  - +120°C to +130°C  $\pm 2.0^\circ\text{C}$  (max)
  - +160°C to +175°C  $\pm 2.0^\circ\text{C}$  (max)
  - -40°C to +120°C  $\pm 3.5^\circ\text{C}$  (max)
- Temperature Resolution
  - 13-bit mode 0.0625°C/LSB
  - 16-bit mode 0.0078125°C/LSB

### Conversion Time

- 13-bit mode 43 ms (max)
- 16-bit mode 350 ms (max)

### DESCRIPTION

The LM95172EWG is an integrated digital-output temperature sensor with a Serial Peripheral Interface (SPI) and MICROWIRE™-compatible interface in a 10-pin Cerpack high temperature ceramic package. It features a very linear Sigma-Delta Analog-to-Digital Converter (ADC), high accuracy, fast conversion rates, and extremely low output noise. With an operating temperature as low as -40°C and optimized accuracy from 120°C to 200°C, it is ideal for high-temperature applications.

The over-temperature alarm output ( $\overline{\text{OVERTEMP}}$ ) asserts when the die temperature exceeds a programmed  $T_{\text{HIGH}}$  limit. The user-programmed  $T_{\text{LOW}}$  limit creates a temperature-stabilizing hysteresis when the ambient temperature is near the trip point.

The LM95172EWG can be programmed to operate from 13 bits (0.0625°C per LSB) to 16 bits (0.0078125°C per LSB) resolution. The LM95172EWG powers up in 35 ms, the fastest conversion time, with temperature output set at 13-bit resolution. The resolution may then be changed to 14-, 15- or 16-bits. When in the 13-, 14- or 15-bit resolution mode, the least significant bit in the 16-bit temperature register toggles after the completion of each conversion. This bit may be monitored to verify that the conversion is complete.

The high noise immunity of the Serial I/O (SI/O) output makes the LM95172EWG ideal for use in challenging electromagnetic environments.

### Connection Diagram

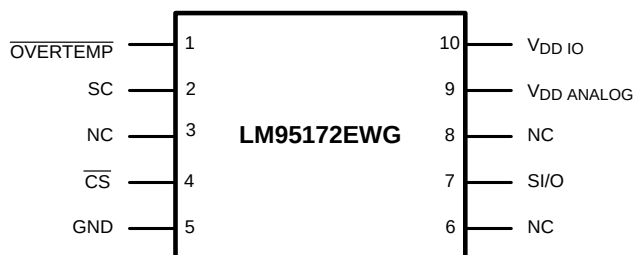


Figure 1. LM95172EWG- Top View



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

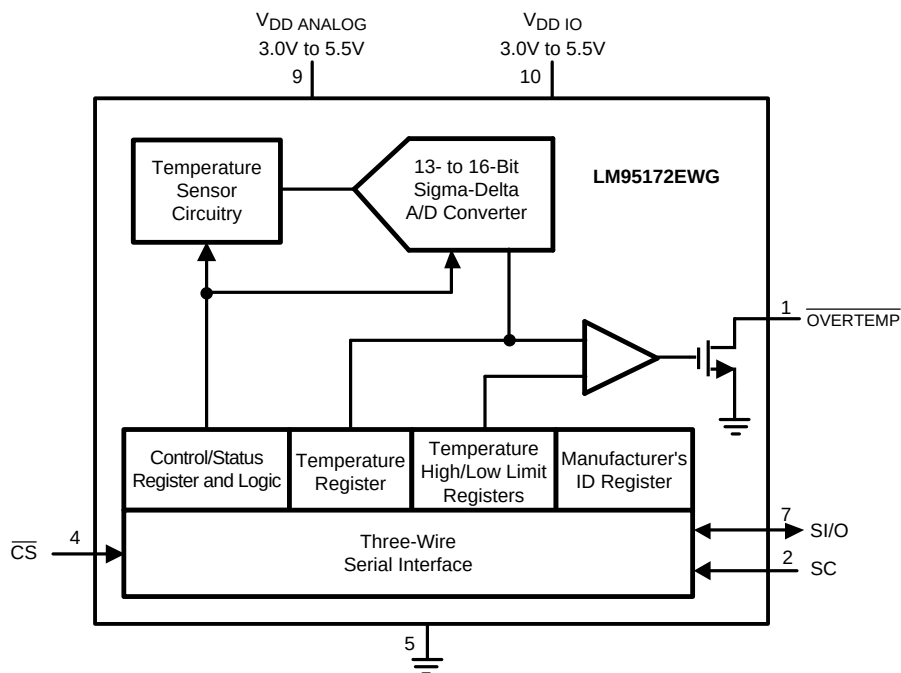
PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

Copyright © 2009–2013, Texas Instruments Incorporated

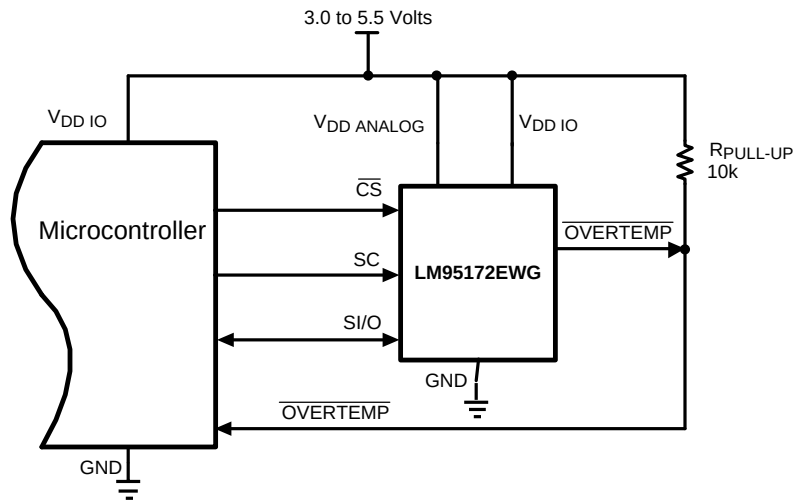
## PIN DESCRIPTIONS

| Pin Number | Name                         | Type          | Description                        | Typical Connection                                                                                                |
|------------|------------------------------|---------------|------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| 1          | $\overline{\text{OVERTEMP}}$ | Output        | $\overline{\text{OVERTEMP}}$ Alarm | Over-temperature Alarm Output, Open-drain. Active Low on POR. Requires a pull-up resistor to $V_{\text{DD IO}}$ . |
| 2          | SC                           | Input         | Serial Clock input                 | Serial clock from the Controller                                                                                  |
| 3          | NC                           | N/A           | No Connect                         | Do not connect to this pin.                                                                                       |
| 4          | $\overline{\text{CS}}$       | Input         | Chip Select input                  | Chip Select input for the bus. Low pass filtered.                                                                 |
| 5          | GND                          | Ground        | Power Supply Ground                | Ground                                                                                                            |
| 6          | NC                           | N/A           | No Connect                         | Do not connect to this pin.                                                                                       |
| 7          | SI/O                         | Bidirectional | Serial I/O                         | Serial I/O Data line to or from the Controller                                                                    |
| 8          | NC                           | N/A           | No Connect                         | Do not connect to this pin.                                                                                       |
| 9          | $V_{\text{DD ANALOG}}$       | Power         | Analog Power Supply Voltage        | DC Voltage from 3.0V to 5.5V. Bypass with a 10 nF ceramic capacitor near the pad to ground.                       |
| 10         | $V_{\text{DD IO}}$           | Power         | Digital Power Supply Voltage       | DC Voltage from 3.0V to 5.5V. Bypass with a 10 nF ceramic capacitor near the pin to ground.                       |

## Simplified Block Diagram



## Typical Application



**Figure 2. Microcontroller Interface - normal connection**



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>

|                                                               |                                      |
|---------------------------------------------------------------|--------------------------------------|
| V <sub>DD ANALOG</sub> and V <sub>DD IO</sub> Supply Voltages | –0.2V to 6.0V                        |
| Voltage at any Pin                                            | –0.2V to (V <sub>DD IO</sub> + 0.2V) |
| Input Current at any Pin                                      | 5 mA                                 |
| Storage Temperature                                           | –65°C to +175°C                      |
| Soldering Information<br>Infrared or Convection (20 sec.)     | 235°C                                |
| ESD Susceptibility <sup>(2)</sup><br>Human Body Model         | 2500 V                               |
| Machine Model                                                 | 250 V                                |
| Charged Device Model                                          | 1000 V                               |

- (1) “Absolute Maximum Ratings” indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the Absolute Maximum Ratings or other conditions beyond those indicated in the Operating Ratings is not implied. The Operating Ratings indicate conditions at which the device is functional and the device should not be operated beyond such conditions.
- (2) Human body model, 100 pF discharged through a 1.5 kΩ resistor. Machine model, 200 pF discharged directly into each pin. The Charged Device Model (CDM) is a specified circuit characterizing an ESD event that occurs when a device acquires charge through some triboelectric (frictional) or electrostatic induction processes and then abruptly touches a grounded object or surface.

## Operating Ratings

|                                                       |                 |
|-------------------------------------------------------|-----------------|
| Specified Temperature Range                           | –40°C to +200°C |
| Analog Supply Voltage Range<br>V <sub>DD ANALOG</sub> | +3.0V to +5.5V  |
| Digital Supply Voltage Range<br>V <sub>DD IO</sub>    | +3.0V to +5.5V  |

## Package Thermal Resistances

| Package         | θ <sub>JA</sub> |
|-----------------|-----------------|
| 10-Lead CERPACK | 175°C/W         |

## Temperature-to-Digital Converter Characteristics

Unless otherwise noted, these specifications apply for  $V_{DD\ ANALOG} = V_{DD\ IO} = 3.0V$  to  $3.6V$ .<sup>(1)</sup> **Boldface limits apply for  $T_A = -40^{\circ}C$  to  $+200^{\circ}C$** ; all other limits  $T_A = 25^{\circ}C$ , unless otherwise noted.

| Parameter                                  | Conditions                                 |                                        | Typical <sup>(2)</sup> | LM95172EWG Limits <sup>(3)</sup> | Units (Limit)       |
|--------------------------------------------|--------------------------------------------|----------------------------------------|------------------------|----------------------------------|---------------------|
| Temperature Accuracy <sup>(1)</sup>        | $T_A = +175^{\circ}C$ to $+200^{\circ}C$   |                                        |                        | <b><math>\pm 3.0</math></b>      | $^{\circ}C$ (max)   |
|                                            | $T_A = +130^{\circ}C$ to $+160^{\circ}C$   |                                        |                        | <b><math>\pm 1.0</math></b>      |                     |
|                                            | $T_A = +120^{\circ}C$ to $+130^{\circ}C$   |                                        |                        | <b><math>\pm 2.0</math></b>      |                     |
|                                            | $T_A = +160^{\circ}C$ to $+175^{\circ}C$   |                                        |                        | <b><math>\pm 2.0</math></b>      |                     |
|                                            | $T_A = -40^{\circ}C$ to $+120^{\circ}C$    |                                        |                        | <b><math>\pm 3.5</math></b>      |                     |
| Resolution                                 | Res 1 Bit<br>0                             | Res 0 Bit<br>0                         | 13<br>0.0625           |                                  | Bits<br>$^{\circ}C$ |
|                                            | 0                                          | 1                                      | 14<br>0.03125          |                                  | Bits<br>$^{\circ}C$ |
|                                            | 1                                          | 0                                      | 15<br>0.015625         |                                  | Bits<br>$^{\circ}C$ |
|                                            | 1                                          | 1                                      | 16<br>0.0078125        |                                  | Bits<br>$^{\circ}C$ |
| Temperature Conversion Time <sup>(4)</sup> | For 13 Bits Resolution                     |                                        |                        | <b>43<sup>(5)</sup></b>          | ms (max)            |
|                                            | For 14 Bits Resolution                     |                                        |                        | <b>87<sup>(5)</sup></b>          |                     |
|                                            | For 15 Bits Resolution                     |                                        |                        | <b>175<sup>(5)</sup></b>         |                     |
|                                            | For 16 Bits Resolution                     |                                        |                        | <b>350<sup>(5)</sup></b>         |                     |
| Total Quiescent Current <sup>(6)</sup>     | Bus Inactive<br>Continuous Conversion Mode | $T_A = -40^{\circ}C$ to $140^{\circ}C$ | 400                    | <b>456</b>                       | $\mu A$ (max)       |
|                                            |                                            | $T_A = -40^{\circ}C$ to $175^{\circ}C$ |                        | <b>510</b>                       |                     |
|                                            |                                            | $T_A = -40^{\circ}C$ to $200^{\circ}C$ | 500                    | <b>650</b>                       |                     |
|                                            | Shutdown Mode                              | $T_A = -40^{\circ}C$ to $140^{\circ}C$ |                        | <b>4</b>                         |                     |
|                                            |                                            | $T_A = -40^{\circ}C$ to $175^{\circ}C$ |                        | <b>12</b>                        |                     |
|                                            |                                            | $T_A = -40^{\circ}C$ to $200^{\circ}C$ | 28                     | <b>75</b>                        |                     |
| Power-On Reset Threshold                   | $T_A = -40^{\circ}C$ to $140^{\circ}C$     |                                        |                        | <b>0.9</b>                       | V (min)             |
|                                            |                                            |                                        |                        | <b>2.1</b>                       | V (max)             |
|                                            | $T_A = -40^{\circ}C$ to $175^{\circ}C$     |                                        |                        | <b>0.8</b>                       | V (min)             |
|                                            |                                            |                                        |                        | <b>2.1</b>                       | V (max)             |
|                                            | $T_A = -40^{\circ}C$ to $200^{\circ}C$     |                                        |                        | <b>0.3</b>                       | V (min)             |
|                                            |                                            |                                        |                        | <b>2.1</b>                       | V (max)             |

- (1) The LM95172EWG will operate properly over the  $V_{DD\ ANALOG} = 3.0V$  to  $5.5V$  and  $V_{DD\ IO} = 3.0V$  to  $5.5V$  supply voltage ranges.
- (2) Typical values represent most likely parametric norms at specific conditions (Example  $V_{CC}$ ; specific temperature) and at the recommended Operating Conditions at the time of product characterizations and are not ensured.
- (3) The Electrical characteristics tables list ensured specifications under the listed Operating Ratings except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not ensured.
- (4) This specification is provided only to indicate how often temperature data is updated. The LM95172EWG 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.
- (5) Specification is ensured by characterization and is not tested in production
- (6) Total Quiescent Current includes the sum of the currents into the  $V_{DD\ ANALOG}$  and the  $V_{DD\ IO}$  pins.

## Logic Electrical Characteristics Digital DC Characteristics

Unless otherwise noted, these specifications apply for  $V_{DD\ ANALOG} = V_{DD\ IO} = 3.0V$  to  $3.6V$ . <sup>(1)</sup> **Boldface limits apply for  $T_A = -40^{\circ}C$  to  $200^{\circ}C$** ; all other limits  $T_A = +25^{\circ}C$ , unless otherwise noted.

| Symbol     | Parameter                          | Conditions                     | Typical <sup>(2)</sup> | Limits <sup>(3)</sup>                      | Units (Limit) |
|------------|------------------------------------|--------------------------------|------------------------|--------------------------------------------|---------------|
| $V_{IH}$   | Logical "1" Input Voltage          |                                |                        | <b><math>0.75 \times V_{DD\ IO}</math></b> | V (min)       |
| $V_{IL}$   | Logical "0" Input Voltage          |                                |                        | <b><math>0.25 \times V_{DD\ IO}</math></b> | V (max)       |
| $V_{HYST}$ | Digital Input Hysteresis           | $V_{DD\ IO} = 3.0V$            | 0.63                   | <b>0.42</b>                                | V (min)       |
|            |                                    | $V_{DD\ IO} = 3.3V$            | 0.79                   | <b>0.56</b>                                |               |
|            |                                    | $V_{DD\ IO} = 3.6V$            | 0.97                   | <b>0.72</b>                                |               |
|            |                                    | $V_{DD\ IO} = 4.5V$            |                        | <b>0.9</b>                                 |               |
|            |                                    | $V_{DD\ IO} = 5.0V$            |                        | <b>1.0</b>                                 |               |
|            |                                    | $V_{DD\ IO} = 5.5V$            |                        | <b>1.1</b>                                 |               |
| $I_{IH}$   | Logical "1" Input Leakage Current  | $V_{IN} = V_{DD\ IO}$          |                        | <b>1</b>                                   | $\mu A$ (max) |
| $I_{IL}$   | Logical "0" Input Current          | $V_{IN} = 0V$                  |                        | <b>-1</b>                                  | $\mu A$ (max) |
| $V_{OH}$   | Output High Voltage                | $I_{OH} = 100\ \mu A$ (Source) |                        | <b><math>V_{DD\ IO} - 0.2</math></b>       | V (min)       |
|            |                                    | $I_{OH} = 2\ mA$ (Source)      |                        | <b><math>V_{DD\ IO} - 0.45</math></b>      |               |
| $V_{OL}$   | Output Low Voltage                 | $I_{OL} = 100\ \mu A$ (Sink)   |                        | <b>0.2</b>                                 | V (max)       |
|            |                                    | $I_{OL} = 2\ mA$ (Sink)        |                        | <b>0.45</b>                                |               |
|            | OVERTEMP Output Saturation Voltage | $I_{OL} = 2\ mA$ (Sink)        |                        | <b>0.45</b>                                | V(max)        |

- (1) The LM95172EWG will operate properly over the  $V_{DD\ ANALOG} = 3.0V$  to  $5.5V$  and  $V_{DD\ IO} = 3.0V$  to  $5.5V$  supply voltage ranges.
- (2) Typical values represent most likely parametric norms at specific conditions (Example  $V_{CC}$ ; specific temperature) and at the recommended Operating Conditions at the time of product characterizations and are not ensured.
- (3) The Electrical characteristics tables list ensured specifications under the listed Operating Ratings except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not ensured.

## Serial Bus Digital Switching Characteristics

Unless otherwise noted, these specifications apply for  $V_{DD\ ANALOG} = V_{DD\ IO} = 3.0V$  to  $3.6V$  <sup>(1)</sup>;  $C_L$  (load capacitance) on output lines =  $100\ pF$  unless otherwise specified. **Boldface limits apply for  $T_A = -40^{\circ}C$  to  $200^{\circ}C$** ; all other limits  $T_A = +25^{\circ}C$ , unless otherwise noted.

| Symbol    | Parameter                                                                                           | Typical <sup>(2)</sup> | Limits <sup>(3)</sup> | Units (Limit) |
|-----------|-----------------------------------------------------------------------------------------------------|------------------------|-----------------------|---------------|
| $t_1$     | SC (Serial Clock) Period                                                                            |                        | <b>765</b>            | ns (min)      |
| $t_2$     | $\overline{CS}$ (Chip Select) Low to SC High Set-Up Time <sup>(4)(5)</sup>                          |                        | <b>1.25</b>           | $\mu s$ (min) |
| $t_3$     | $\overline{CS}$ Low to SI/O Output Delay <sup>(4)(5)</sup>                                          |                        | <b>1</b>              | $\mu s$ (max) |
| $t_4$     | SC Low to SI/O Output Delay                                                                         |                        | <b>120</b>            | ns (max)      |
| $t_5$     | $\overline{CS}$ High to Data Out (SI/O) TRI-STATE                                                   |                        | <b>220</b>            | ns (max)      |
| $t_6$     | SC High to SI/O Input Hold Time                                                                     |                        | <b>50</b>             | ns (min)      |
| $t_7$     | SI/O Input to SC High Set-Up Time                                                                   |                        | <b>30</b>             | ns (min)      |
| $t_8$     | SC Low to $\overline{CS}$ High Hold Time                                                            |                        | <b>50</b>             | ns (min)      |
| $t_{TA}$  | Data Turn-Around Time: SI/O input (write to LM95172EWG) to output (read from LM95172EWG)            |                        | <b>130</b>            | ns (max)      |
| $t_{BUF}$ | Bus free time between communications: $\overline{CS}$ High to $\overline{CS}$ Low <sup>(4)(5)</sup> |                        | <b>5</b>              | $\mu s$ (min) |

- (1) The LM95172EWG will operate properly over the  $V_{DD\ ANALOG} = 3.0V$  to  $5.5V$  and  $V_{DD\ IO} = 3.0V$  to  $5.5V$  supply voltage ranges.
- (2) Typical values represent most likely parametric norms at specific conditions (Example  $V_{CC}$ ; specific temperature) and at the recommended Operating Conditions at the time of product characterizations and are not ensured.
- (3) The Electrical characteristics tables list ensured specifications under the listed Operating Ratings except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not ensured.
- (4) Specification is ensured by characterization and is not tested in production
- (5) Specification is ensured by design and is not tested in production

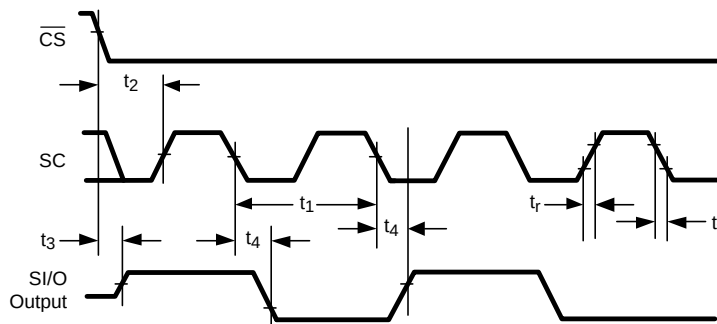


Figure 3. Data Output Timing Diagram

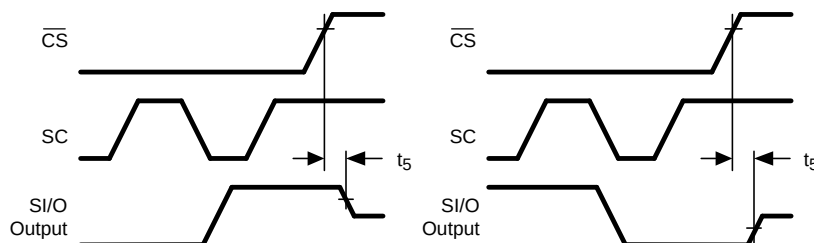


Figure 4. TRI-STATE Data Output Timing Diagram

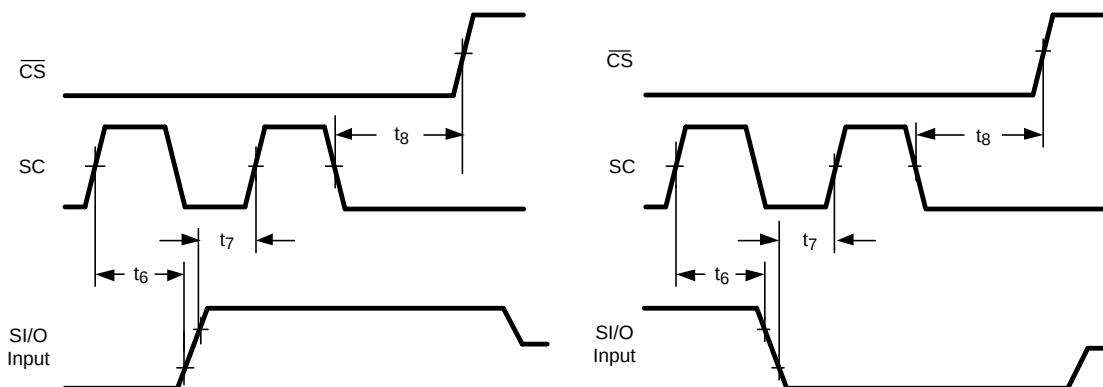
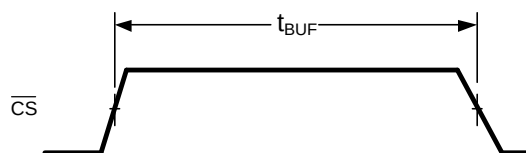
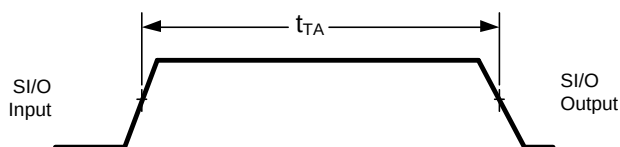
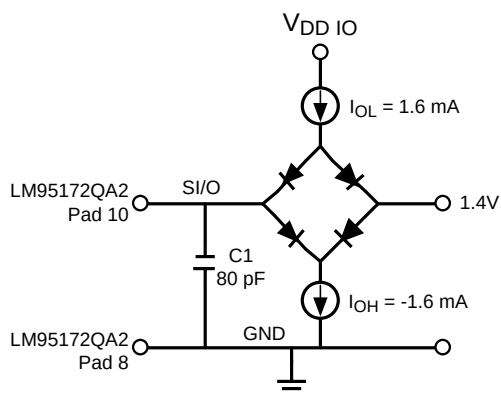


Figure 5. Data Input Timing Diagram

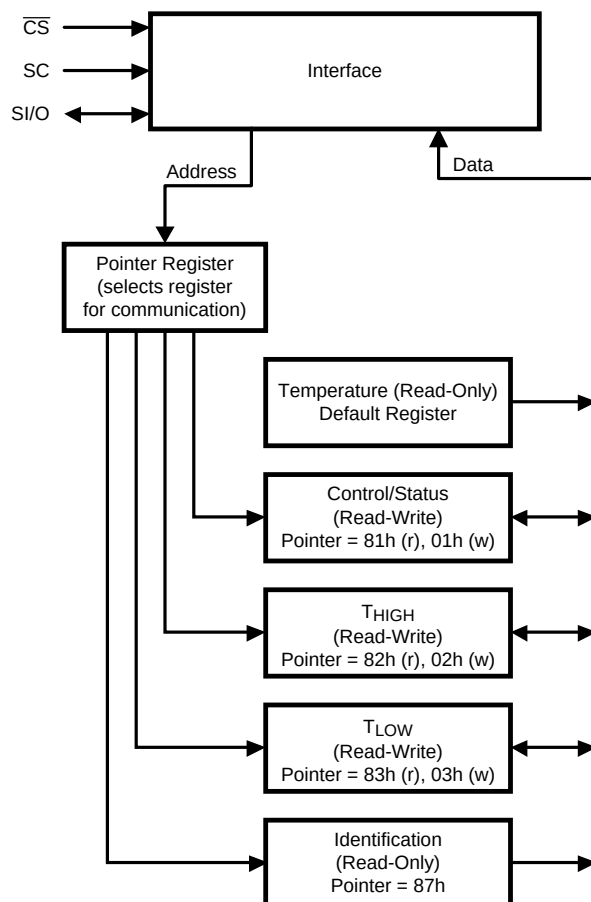
Figure 6.  $t_{BUF}$  Timing Definition DiagramFigure 7.  $t_{TA}$  Timing Definition Diagram

**Figure 8. TRI-STATE Test Circuit**



## FUNCTIONAL DESCRIPTION

The LM95172EWG temperature sensor incorporates a temperature sensor and a 13-bit to 16-bit  $\Sigma\Delta$  ADC (Sigma-Delta Analog-to-Digital Converter). Compatibility of the LM95172EWG'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/Device ID register identifies the LM95172EWG as Texas Instruments product. See [Figure 9](#).



**Figure 9. LM95172EWG Functional Block Diagram**

## INITIAL SOFTWARE RESET AND POWER-UP SEQUENCES AND POWER ON RESET (POR)

### Software Reset Sequence

A software reset sequence must be followed, after the initial  $V_{DD\text{ ANALOG}}$  and  $V_{DD\text{ IO}}$  supply voltages reach their specified minimum operating voltages, in order to ensure proper operation of the LM95172EWG.

The software reset sequence is as follows:

1. Allow  $V_{DD\text{ ANALOG}}$  and  $V_{DD\text{ IO}}$  to reach their specified minimum operating voltages, as specified in [Operating Ratings](#), and in a manner as specified in [Power-Up Sequence](#).
2. Write a "1" to the Shutdown bit, Bit 15 of the Control/Status Register, and hold it high for at least the specified maximum conversion time for the initial default of 13-bits resolution, in order to ensure that a complete reset operation has occurred. (See the Temperature Conversion Time specifications within [Temperature-to-Digital Converter Characteristics](#).)
3. Write a "0" to the Shutdown bit to restore the LM95172EWG to normal mode.
4. Wait for at least the specified maximum conversion time for the initial default of 13-bits resolution in order to ensure that accurate data appears in the Temperature Register.



## Power-Up Sequence

### WARNING

In all cases listed below the  $V_{DD\ ANALOG}$  waveform must not lag the  $V_{DD\ IO}$  waveform

**Linear Power-up** In the case where the  $V_{DD\ ANALOG}$  and  $V_{DD\ IO}$  voltage-vs.-time function is linear, the specified minimum operating voltage must be reached in 5 ms or less.

**Resistor-Capacitor (R-C) Charging Exponential Power-up** In the case where the  $V_{DD\ ANALOG}$  and  $V_{DD\ IO}$  voltage-vs.-time function is as a typical R-C Charging exponential function the time constant must be less than or equal to 1.25 ms.

**Other Power-up Functions** In the case where the  $V_{DD\ ANALOG}$  and  $V_{DD\ IO}$  voltage-vs.-time characteristic follows another function the following requirements must be met:

1. The specified minimum operating voltage values for  $V_{DD\ ANALOG}$  and  $V_{DD\ IO}$  must be reached in 5 ms or less.
2. The slope of the  $V_{DD\ ANALOG}$  and  $V_{DD\ IO}$  power-up curves must be greater than or equal to 0.7 V/ms at any time before the specified minimum operating voltage is reached.
3. The slope of the  $V_{DD\ ANALOG}$  and  $V_{DD\ IO}$  power-up curves must not allow ringing such that the voltage is allowed to drop below the specified minimum operating voltage at any time after the specified minimum operating voltage is reached.

## Power On Reset (POR)

After the requirements of [Software Reset Sequence](#) and [Power-Up Sequence](#) are met each register will then contain its defined POR default value. Any of the following actions may cause register values to change from their POR value:

1. The master writes different data to any Read/Write (R/W) bits, or
2. The LM95172EWG is powered down.

The specific POR Value of each register is listed in [INTERNAL REGISTER STRUCTURE](#).

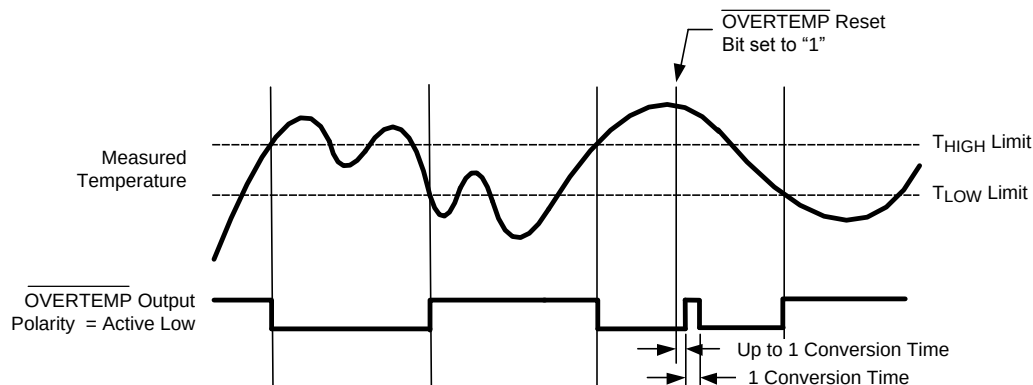
## ONE SHOT CONVERSION

The LM95172EWG features a one-shot conversion bit, which is used to initiate a single conversion and comparison cycle when the LM95172EWG is in shutdown mode. While the LM95172EWG is in shutdown mode, writing a "1" to the One-Shot bit in the Control/Status Register will cause the LM95172EWG to perform a single temperature conversion and update the Temperature Register and the affected status bits. Operating the LM95172EWG in this one-shot mode allows for extremely low average-power consumption, making it ideal for low-power applications.

When the One-shot bit is set, the LM95172EWG initiates a temperature conversion. After this initiation, but before the completion of the conversion, and resultant register updates, the LM95172EWG is in a "one-shot" state. During this state, the Data Available (DAV) flag in the Control/Status Register is "0" and the Temperature Register contains the value 8000h (-256°C). All other registers contain the data that was present before initiating the one-shot conversion. After the temperature measurement is complete, the DAV flag will be set to "1" and the temperature register will contain the resultant measured temperature.

## OVERTEMP OUTPUT

The Over-temperature ( $\overline{OVERTEMP}$ ) output is a temperature switch signal that indicates when the measured temperature exceeds the  $T_{HIGH}$  programmed limit. The programmable  $T_{HIGH}$  register sets the high temperature limit and the  $T_{LOW}$  register is used to set the hysteresis. The  $T_{LOW}$  register also sets the temperature below which the  $\overline{OVERTEMP}$  output resets. The  $\overline{OVERTEMP}$  output of the LM95172EWG behaves as a temperature comparator. The following explains the operation of  $\overline{OVERTEMP}$ . [Figure 10](#) illustrates the  $\overline{OVERTEMP}$  output behavior.



NOTE: The  $\overline{\text{OVERTEMP}}$  output asserts when the measured temperature is *greater than* the  $T_{\text{HIGH}}$  value.

**Figure 10. LM95172EWG  $\overline{\text{OVERTEMP}}$  vs. Temperature Response Diagram**

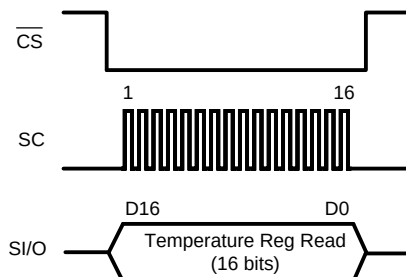
The  $\overline{\text{OVERTEMP}}$  Output will assert when the measured temperature is greater than the  $T_{\text{HIGH}}$  value.  $\overline{\text{OVERTEMP}}$  will reset if any of the following events happen:

1. The temperature falls below the value stored in the  $T_{\text{LOW}}$  register, or
2. A "1" is written to the  $\overline{\text{OVERTEMP}}$  Reset bit in the Control/Status Register.

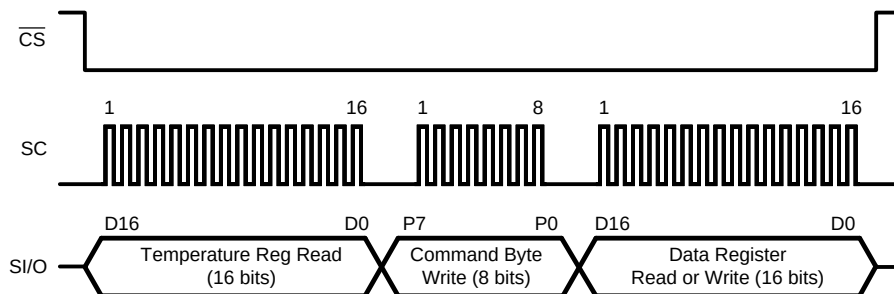
If  $\overline{\text{OVERTEMP}}$  is cleared by the master writing a "1" to the  $\overline{\text{OVERTEMP}}$  Reset bit while the measured temperature still exceeds the  $T_{\text{HIGH}}$  value,  $\overline{\text{OVERTEMP}}$  will assert again after the completion of the next temperature conversion. Placing the LM95172EWG in shutdown mode or triggering a one-shot conversion does not cause  $\overline{\text{OVERTEMP}}$  to reset.

### COMMUNICATING WITH THE LM95172EWG

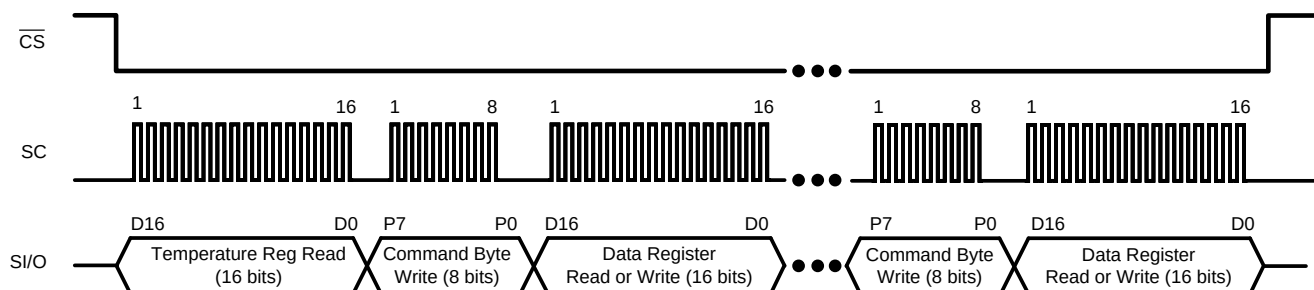
The serial interface consists of three lines:  $\overline{\text{CS}}$  (Chip Select), SC (Serial Clock), and the bi-directional SI/O (Serial I/O) data line. A high-to-low transition of the  $\overline{\text{CS}}$  line initiates the communication. The master (processor) always drives the chip select and the clock. The first 16 clocks shift the temperature data out of the LM95172EWG on the SI/O line (a temperature read). Raising the  $\overline{\text{CS}}$  at anytime during the communication will terminate this read operation. Following this temperature read, the SI/O line becomes an input and a command byte can be written to the LM95172EWG. This command byte contains a R/W bit and the address of the register to be communicated with next (see [INTERNAL REGISTER STRUCTURE](#)). When writing, the data is latched in after every 8 bits. The processor must write at least 8 bits in order to latch the data. If  $\overline{\text{CS}}$  is raised before the falling edge of the 8th command bit, no data will be latched into the command byte. If  $\overline{\text{CS}}$  is raised after the 8th bit, but before the 16th bit, of a write to a 16-bit data register, only the most significant byte of the data will be latched. This command-data-command-data sequence may be performed as many times as desired.



**Figure 11. Reading the Temperature Register**



**Figure 12. Reading the Temperature Register followed by a read or write from another register (Control/Status,  $T_{HIGH}$ ,  $T_{LOW}$ , or Identification register)**



**Figure 13. Reading the Temperature Register followed by repeated commands and Data Register accesses (Control/Status,  $T_{HIGH}$ ,  $T_{LOW}$ , or Identification register)**

## TEMPERATURE DATA FORMAT

Temperature data is represented by a 13- to 16-bit, two's complement word with a Least Significant Bit (LSB) equal to 0.0625 °C (13-bits), 0.03125 °C (14-bits), 0.015625 °C (15-bits) or 0.0078125 °C (16-bits). See [Temperature Register](#) for definition of the bits in the Temperature Register.

**Table 1. 13-Bit Resolution. First Bit (D15) is Sign, the last bit (D0) is Toggle and bits D1 and D2 are always 0.**

| Temperature | 13-bit Resolution Digital Output |             |               |
|-------------|----------------------------------|-------------|---------------|
|             | 16-bit Binary                    | All 16 Bits | Bits D15 - D3 |
|             |                                  | Hex         | Hex           |
| +175°C      | 0101011110000 000                | 5780        | 0AF0          |
|             | 0101011110000 001                | 5781        |               |
| +150°C      | 0100101100000 000                | 4B00        | 0960          |
|             | 0100101100000 001                | 4B01        |               |
| +80°C       | 0010100000000 000                | 2800        | 0500          |
|             | 0010100000000 001                | 2801        |               |
| +25°C       | 0000110010000 000                | 0C80        | 0190          |
|             | 0000110010000 001                | 0C81        |               |
| +0.0625°C   | 0000000000001 000                | 0008        | 0001          |
|             | 0000000000001 001                | 0009        |               |
| 0°C         | 0000000000000 000                | 0000        | 0000          |
|             | 0000000000000 001                | 0001        |               |
| -0.0625°C   | 1111111111111 000                | FFF8        | 1FFF          |
|             | 1111111111111 001                | FFF9        |               |

**Table 1. 13-Bit Resolution. First Bit (D15) is Sign, the last bit (D0) is Toggle and bits D1 and D2 are always 0. (continued)**

| Temperature | 13-bit Resolution Digital Output |             |               |
|-------------|----------------------------------|-------------|---------------|
|             | 16-bit Binary                    | All 16 Bits | Bits D15 - D3 |
|             |                                  | Hex         | Hex           |
| -40°C       | 1110110000000 000                | EC00        | 1D80          |
|             | 1110110000000 001                | EC01        |               |

**Table 2. 14-Bit Resolution. First bit (D15) is Sign, the last bit (D0) is Toggle and bit D1 is always 0.**

| Temperature | 14-bit Resolution Digital Output |             |               |
|-------------|----------------------------------|-------------|---------------|
|             | 16-bit Binary                    | All 16 Bits | Bits D15 - D2 |
|             |                                  | Hex         | Hex           |
| +175°C      | 01010111100000 00                | 5780        | 15E0          |
|             | 01010111100000 01                | 5781        |               |
| +150°C      | 01001011000000 00                | 4B00        | 12C0          |
|             | 01001011000000 01                | 4B01        |               |
| +80°C       | 00101000000000 00                | 2800        | 0A00          |
|             | 00101000000000 01                | 2801        |               |
| +25°C       | 00001100100000 00                | 0C80        | 0320          |
|             | 00001100100000 01                | 0C81        |               |
| +0.03125°C  | 00000000000001 00                | 0004        | 0001          |
|             | 00000000000001 01                | 0005        |               |
| 0°C         | 00000000000000 00                | 0000        | 0000          |
|             | 00000000000000 01                | 0001        |               |
| -0.03125°C  | 11111111111111 00                | FFFC        | 3FFF          |
|             | 11111111111111 01                | FFFD        |               |
| -40°C       | 11101100000000 00                | EC00        | 3B00          |
|             | 11101100000000 01                | EC01        |               |

**Table 3. 15-Bit Resolution. First bit (D15) is Sign and the last bit (D0) is Toggle.**

| Temperature | 15-bit Resolution Digital Output |             |               |
|-------------|----------------------------------|-------------|---------------|
|             | 16-bit Binary                    | All 16 Bits | Bits D15 - D1 |
|             |                                  | Hex         | Hex           |
| +175°C      | 010101111000000 0                | 5780        | 2BC0          |
|             | 010101111000000 1                | 5781        |               |
| +150°C      | 010010110000000 0                | 4B00        | 2580          |
|             | 010010110000000 1                | 4B01        |               |
| +80°C       | 001010000000000 0                | 2800        | 1400          |
|             | 001010000000000 1                | 2801        |               |
| +25°C       | 000011001000000 0                | 0C80        | 0640          |
|             | 000011001000000 1                | 0C81        |               |
| +0.015625°C | 000000000000001 0                | 0002        | 0001          |
|             | 000000000000001 1                | 0003        |               |
| 0°C         | 000000000000000 0                | 0000        | 0000          |
|             | 000000000000000 1                | 0001        |               |
| -0.015625°C | 111111111111111 0                | FFFE        | 7FFF          |
|             | 111111111111111 1                | FFFF        |               |
| -40°C       | 111011000000000 0                | EC00        | 7600          |
|             | 111011000000000 1                | EC01        |               |

**Table 4. 16-Bit Resolution. First bit (D15) is Sign and the last bit (D0) is the LSB.**

| Temperature  | 16-bit Resolution Digital Output |             |
|--------------|----------------------------------|-------------|
|              | 16-bit Binary                    | All 16 Bits |
|              |                                  | Hex         |
| +175°C       | 0101 0111 1000 0000              | 5780        |
| +150°C       | 0100 1011 0000 0000              | 4B00        |
| +80°C        | 0010 1000 0000 0000              | 2800        |
| +25°C        | 0000 1100 1000 0000              | 0C80        |
| +0.0078125°C | 0000 0000 0000 0001              | 0001        |
| 0°C          | 0000 0000 0000 0000              | 0000        |
| -0.0078125°C | 1111 1111 1111 1111              | FFFF        |
| -40°C        | 1110 1100 0000 0000              | EC00        |

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

Shutdown Mode is enabled by writing a “1” to the Shutdown Bit, Bit 15 of the Control/Status Register, and holding it high for at least the specified maximum conversion time at the existing temperature resolution setting. (see Temperature Conversion Time specifications under the [Temperature-to-Digital Converter Characteristics](#)). For example, if the LM95172EWG is set for 16-bit resolution before shutdown, then Bit 15 of the Control/Status register must go high and stay high for the specified maximum conversion time for 16-bits resolution.

The LM95172EWG will always finish a temperature conversion and update the temperature registers before shutting down.

Writing a “0” to the Shutdown Bit restores the LM95172EWG to normal mode.

## INTERNAL REGISTER STRUCTURE

The LM95172EWG has four registers that are accessible by issuing a command byte (a  $\overline{R/\overline{W}}$  Bit plus the register address: Control/Status,  $T_{HIGH}$ ,  $T_{LOW}$ , and Identification. Which of these registers will be read or written is determined by the Command Byte. See [COMMUNICATING WITH THE LM95172EWG](#) for a complete description of the serial communication protocol. The following diagram describes the Command Byte and lists the addresses of the various registers. On power-up, the Command Byte will point to the Temperature Register by default. The temperature is read by lowering the CS line and then reading the 16-Bit temperature register; all other registers are accessed by writing a Command Byte after reading the temperature.

All registers can be communicated with, either in Continuous Conversion mode or in Shutdown mode. When the LM95172EWG has been placed in Shutdown Mode, the Temperature register will contain the temperature data which resulted from the last temperature conversion (whether it was the result of a continuous-conversion reading or a one-shot reading).

### Command Byte

| P7                          | P6 | P5 | P4 | P3 | P2              | P1 | P0 |
|-----------------------------|----|----|----|----|-----------------|----|----|
| $\overline{R/\overline{W}}$ | 0  | 0  | 0  | 0  | Register Select |    |    |

Bit <7> Read/ $\overline{Write}$  Bit. Tells the LM95172EWG if the host will be writing to, or reading from, the register to which this byte is pointing.

Bits <6:3> Not Used. **These Bits must be zero.** If an illegal address is written, the LM95172EWG will return 0000h on the subsequent read.

Bits <2:0> Pointer Address Bits. Points to desired register. See table below.

| P2 | P1 | P0 | Register                |
|----|----|----|-------------------------|
| 0  | 0  | 0  | Invalid. <sup>(1)</sup> |
| 0  | 0  | 1  | Control/Status          |
| 0  | 1  | 0  | T <sub>HIGH</sub>       |
| 0  | 1  | 1  | T <sub>LOW</sub>        |
| 1  | 0  | 0  | Invalid. <sup>(1)</sup> |
| 1  | 0  | 1  |                         |
| 1  | 1  | 0  |                         |
| 1  | 1  | 1  | Identification          |

(1) Invalid. The LM95172EWG will return a "0" if read. If written to, no valid register will be modified.

Power-On Reset state: 00h

Reset Conditions: Upon Power-on Reset

### Temperature Register

(Read Only): Default Register

| D15  | D14   | D13  | D12  | D11  | D10 | D9  | D8  |
|------|-------|------|------|------|-----|-----|-----|
| Sign | 128°C | 64°C | 32°C | 16°C | 8°C | 4°C | 2°C |

| D7  | D6    | D5     | D4      | D3       | D2        | D1         | D0                               |
|-----|-------|--------|---------|----------|-----------|------------|----------------------------------|
| 1°C | 0.5°C | 0.25°C | 0.125°C | 0.0625°C | 0.03125°C | 0.015625°C | Conversion - Toggle/ 0.0078125°C |

Bit <15:1>: Temperature Data Byte. Represents the temperature that was measured by the most recent temperature conversion in two's complement form. On power-up, this data is invalid until the DAV Bit in the Control/Status Register is high (that is, after completion of the first conversion).

The resolution is user-programmable from 13-Bit resolution (0.0625°C) through 16-Bit resolution (0.0078125°C). The desired resolution is programmed through Bits 4 and 5 of the Control/Status Register. See the description of [Control/Status Register](#) for details on resolution selection.

The Bits not used for a selected resolution are always set to "0" and are not to be considered part of a valid temperature reading. For example, for 14-Bit resolution, Bit <1> is not used and, therefore, it is invalid and is always zero.

Bit <0>: Conversion Toggle or, if 16-Bit resolution has been selected, this is the 16-Bit temperature LSB.

When in 13-Bit, 14-Bit, or 15-Bit resolution mode, this Bit toggles each time the Temperature register is read **if** a conversion has completed since the last read. If conversion has not completed, the value will be the same as the last read.

When in 16-Bit resolution mode, this is the Least Significant Bit of the temperature data.

Reset Conditions: See [Software Reset Sequence](#), [Power-Up Sequence](#), and [INITIAL SOFTWARE RESET AND POWER-UP SEQUENCES AND POWER ON RESET \(POR\)](#) for reset conditions.

One-Shot State: 8000h (-256°C)

### Control/Status Register

(Read/Write) Pointer Address: 81h (Read); 01h (Write)

| D15 | D14      | D13            | D12               | D11             | D10               | D9               | D8  |
|-----|----------|----------------|-------------------|-----------------|-------------------|------------------|-----|
| SD  | One-Shot | OVERTEMP Reset | Conversion Toggle | OVERTEMP Status | T <sub>HIGH</sub> | T <sub>LOW</sub> | DAV |

| D7               | D6           | D5   | D4   | D3 | D2       | D1       | D0 |
|------------------|--------------|------|------|----|----------|----------|----|
| OVERTEMP Disable | OVERTEMP POL | RES1 | RES0 | 0  | reserved | reserved | 0  |

Bit <15>: Shutdown (SD) Bit. Writing a "1" to this bit and holding it high for at least the specified maximum conversion time, at the existing temperature resolution setting, enables the Shutdown Mode. Writing a "0" to this bit restores the LM95172EWG to normal mode.

Bit <14>: One-Shot Bit. When in shutdown mode (Bit <15> is "1"), initiates a single temperature conversion and update of the temperature register with new temperature data. Has no effect when in continuous conversion mode (i.e., when Bit <15> is "0"). Always returns a "0" when read.

Bit <13>:  $\overline{\text{OVERTEMP}}$  Reset Bit. Writing a "1" to this Bit resets the  $\overline{\text{OVERTEMP}}$  Status bit and, after a possible wait up to one temperature conversion time, the  $\overline{\text{OVERTEMP}}$  pin. It will always return a "0" when read.

Bit <12>: Conversion Toggle Bit. Toggles each time the Control/Status register is read **if** a conversion has completed since the last read. If conversion has not been completed, the value will be the same as last read.

Bit <11>:  $\overline{\text{OVERTEMP}}$  Status Bit. This Bit is "0" when  $\overline{\text{OVERTEMP}}$  output is low and "1" when  $\overline{\text{OVERTEMP}}$  output is high. The  $\overline{\text{OVERTEMP}}$  output is reset under the following conditions: (1) Cleared by writing a "1" to the  $\overline{\text{OVERTEMP}}$  Reset Bit (Bit <13>) in this register or (2) Measured temperature falls below the  $T_{\text{LOW}}$  limit. If the temperature is still above  $T_{\text{HIGH}}$ , and  $\overline{\text{OVERTEMP}}$  Reset is set to "1", then the Bit and the pin clear until the next conversion, at which point the Bit and pin would assert again.

Bit <10>: Temperature High ( $T_{\text{HIGH}}$ ) Flag Bit. This Bit is set to "1" when the measured temperature exceeds the  $T_{\text{HIGH}}$  limit stored in the programmable  $T_{\text{HIGH}}$  register. The flag is reset to "0" when both of two conditions are met: (1) temperature no longer exceeds the programmed  $T_{\text{HIGH}}$  limit **and** (2) upon reading the Control/Status Register. If the temperature no longer exceeds the  $T_{\text{HIGH}}$  limit, the status Bit remains set until it is read by the master so that the system can check the history of what caused the  $\overline{\text{OVERTEMP}}$  to assert.

Bit <9>: Temperature Low ( $T_{\text{LOW}}$ ) Flag Bit. This Bit is set to "1" when the measured temperature falls below the  $T_{\text{LOW}}$  limit stored in the programmable  $T_{\text{LOW}}$  register. The flag is reset to "0" when both of two conditions are met: (1) temperature is no longer below the programmed  $T_{\text{LOW}}$  limit **and** (2) upon reading the Control/Status Register. If the temperature is no longer below, or equal to, the  $T_{\text{LOW}}$  limit, the status Bit remains set until it is read by the master so that the system can check the history of what caused the  $\overline{\text{OVERTEMP}}$  to assert.

Bit <8>: Data Available (DAV) Status Bit. This Bit is "0" when the temperature sensor is in the process of converting a new temperature. It is "1" when the conversion is done. It is reset after each read and goes high again after one temperature conversion is done. In one-shot mode: after initiating a temperature conversion while operating, this status Bit can be monitored to indicate when the conversion is done. After triggering the one-shot conversion, the data in the temperature register is invalid until this Bit is high (i.e., after completion of the first conversion).

Bit <7>:  $\overline{\text{OVERTEMP}}$  Disable Bit. When set to "0" the  $\overline{\text{OVERTEMP}}$  output is enabled. When set to "1" the  $\overline{\text{OVERTEMP}}$  output is disabled. This Bit also controls the  $\overline{\text{OVERTEMP}}$  Status Bit (this register, Bit <11>) since that Bit reflects the state of the  $\overline{\text{OVERTEMP}}$  pin.

Bit <6>:  $\overline{\text{OVERTEMP}}$  Polarity Bit. When set to "1",  $\overline{\text{OVERTEMP}}$  is active-high. When "0" it is active-low.

### Control/Status Register (Continued)

Bit <5:4>: Temperature Resolution Bits. Selects one of four user-programmable temperature data resolutions as indicated in the following table.

| Control/Status Register |       | Resolution |           |
|-------------------------|-------|------------|-----------|
| Bit 5                   | Bit 4 | Bits       | °C        |
| 0                       | 0     | 13         | 0.0625    |
| 0                       | 1     | 14         | 0.03125   |
| 1                       | 0     | 15         | 0.015625  |
| 1                       | 1     | 16         | 0.0078125 |

Bit <3>: Always write a zero to this Bit.

Bit <2:1>: Reserved Bits. Will return whatever was last written to them. Value is zero on power-up.

Bit <0>: Always write a zero to this Bit.

Reset State: 0000h

Reset Conditions: Upon Power-on Reset.

### ***T<sub>HIGH</sub>: Upper Limit Register***

(Read/Write) Pointer Address: 82h (Read); 02h (Write)

| D15  | D14   | D13  | D12  | D11  | D10 | D9  | D8  |
|------|-------|------|------|------|-----|-----|-----|
| Sign | 128°C | 64°C | 32°C | 16°C | 8°C | 4°C | 2°C |

| D7  | D6    | D5     | D4       | D3 | D2 | D1 | D0 |
|-----|-------|--------|----------|----|----|----|----|
| 1°C | 0.5°C | 0.25°C | Reserved |    |    |    |    |

Bit <15:5>: Upper-Limit Temperature byte. If the measured temperature, stored in the temperature register, exceeds this user-programmable temperature limit, the OVERTEMP pin will assert and the T<sub>HIGH</sub> flag in the Control/Status register will be set to "1".

Bit <4:0>: Reserved. Returns all zeroes when read.

Reset State: 4880h (+145°C)

Reset Conditions: Upon Power-on Reset.

### ***T<sub>LOW</sub>: Lower Limit Register***

(Read/Write) Pointer Address: 83h (Read); 03h (Write)

| D15  | D14   | D13  | D12  | D11  | D10 | D9  | D8  |
|------|-------|------|------|------|-----|-----|-----|
| Sign | 128°C | 64°C | 32°C | 16°C | 8°C | 4°C | 2°C |

| D7  | D6    | D5     | D4       | D3 | D2 | D1 | D0 |
|-----|-------|--------|----------|----|----|----|----|
| 1°C | 0.5°C | 0.25°C | Reserved |    |    |    |    |

Bit <15:5>: Lower-Limit Temperature byte. If the measured temperature that is stored in the temperature register falls below this user-programmable temperature limit, the OVERTEMP pin will not assert and the T<sub>LOW</sub> flag in the Control/Status register will be set to "1".

Bit <4:0>: Reserved. Returns all zeroes when read.

Reset State: 4600h (+140°C)

Reset Conditions: Upon Power-on Reset.

### ***MFGID: Manufacturer, Product, and Step ID Register***

(Read Only) Pointer Address: 87h

| D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 |
|-----|-----|-----|-----|-----|-----|----|----|
| 1   | 0   | 0   | 0   | 0   | 0   | 0  | 0  |

| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|
| 0  | 0  | 1  | 1  | 0  | 0  | 0  | 0  |

Bit <15:8>: Manufacturer Identification Byte. Always returns 80h to uniquely identify the manufacturer as Texas Instruments Corporation.

Bit <7:4>: Product Identification Nibble. Always returns 30h to uniquely identify this part as the LM95172EWG.

Bit <3:0>: Die Revision Nibble. Returns 0h to uniquely identify the revision level as zero.

Reset State: 8030h

Reset Conditions: Upon Power-on Reset.



## Typical Applications

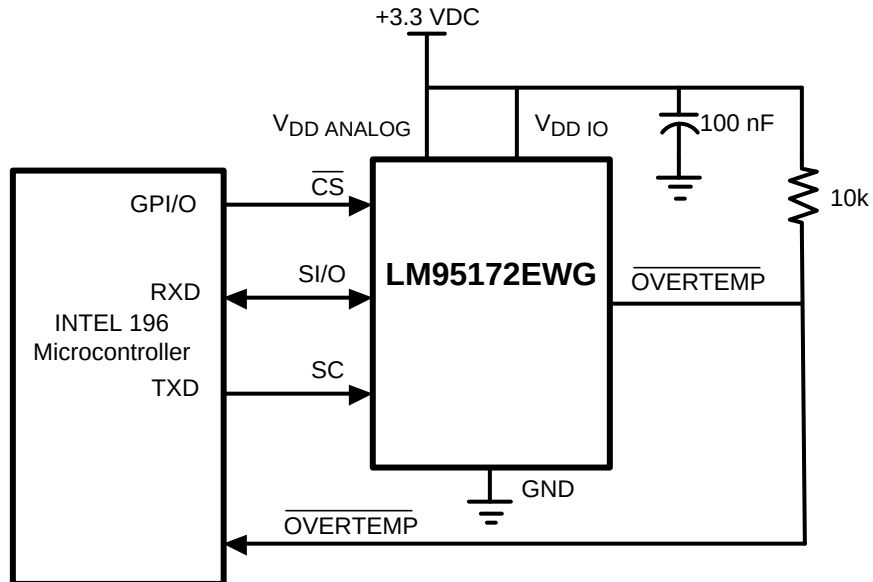


Figure 14. Temperature monitor using Intel 196 processor

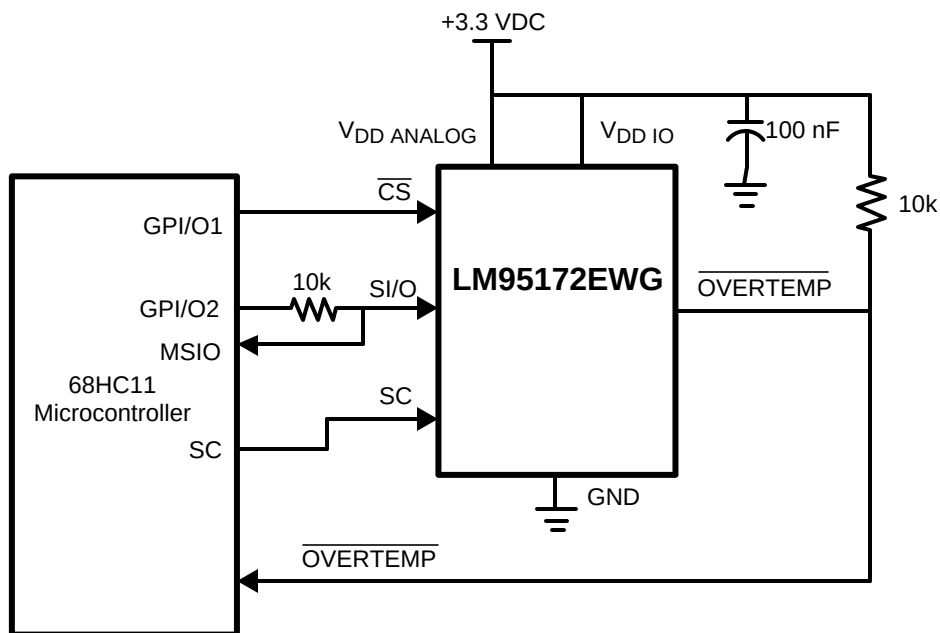


Figure 15. LM95172EWG digital input control using microcontroller's general purpose I/O.

## REVISION HISTORY

| Changes from Revision A (March 2013) to Revision B         | Page               |
|------------------------------------------------------------|--------------------|
| • Changed layout of National Data Sheet to TI format ..... | <a href="#">17</a> |

## PACKAGING INFORMATION

| Orderable part number           | Status<br>(1) | Material type<br>(2) | Package   Pins | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|---------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">LM95172EWG/NOPB</a> | Active        | Production           | CFP (NAC)   10 | 54   TRAY NON-STD     | ROHS Exempt | SNAGCU                               | Level-1-NA-UNLIM                  | -40 to 200   | LM95172<br>EWG      |
| LM95172EWG/NOPB.A               | Active        | Production           | CFP (NAC)   10 | 54   TRAY NON-STD     | ROHS Exempt | SNAGCU                               | Level-1-NA-UNLIM                  | -40 to 200   | LM95172<br>EWG      |

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

<sup>(2)</sup> **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.

<sup>(3)</sup> **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.

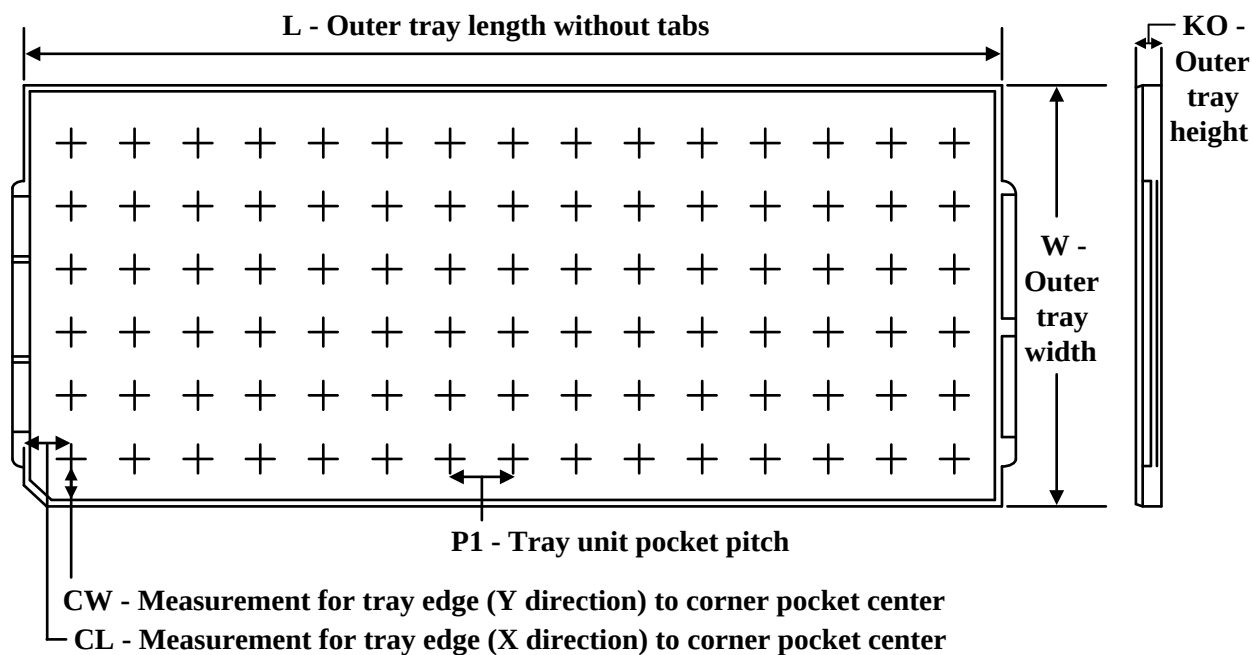
<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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.

**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.

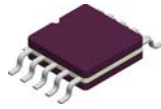
## TRAY



Chamfer on Tray corner indicates Pin 1 orientation of packed units.

\*All dimensions are nominal

| Device            | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (µm) | P1 (mm) | CL (mm) | CW (mm) |
|-------------------|--------------|--------------|------|-----|-------------------|----------------------|--------|--------|---------|---------|---------|---------|
| LM95172EWG/NOPB   | NAC          | CFP          | 10   | 54  | 6 X 9             | 100                  | 101.6  | 101.6  | 8001    | 2.78    | 16.08   | 16.08   |
| LM95172EWG/NOPB.A | NAC          | CFP          | 10   | 54  | 6 X 9             | 100                  | 101.6  | 101.6  | 8001    | 2.78    | 16.08   | 16.08   |

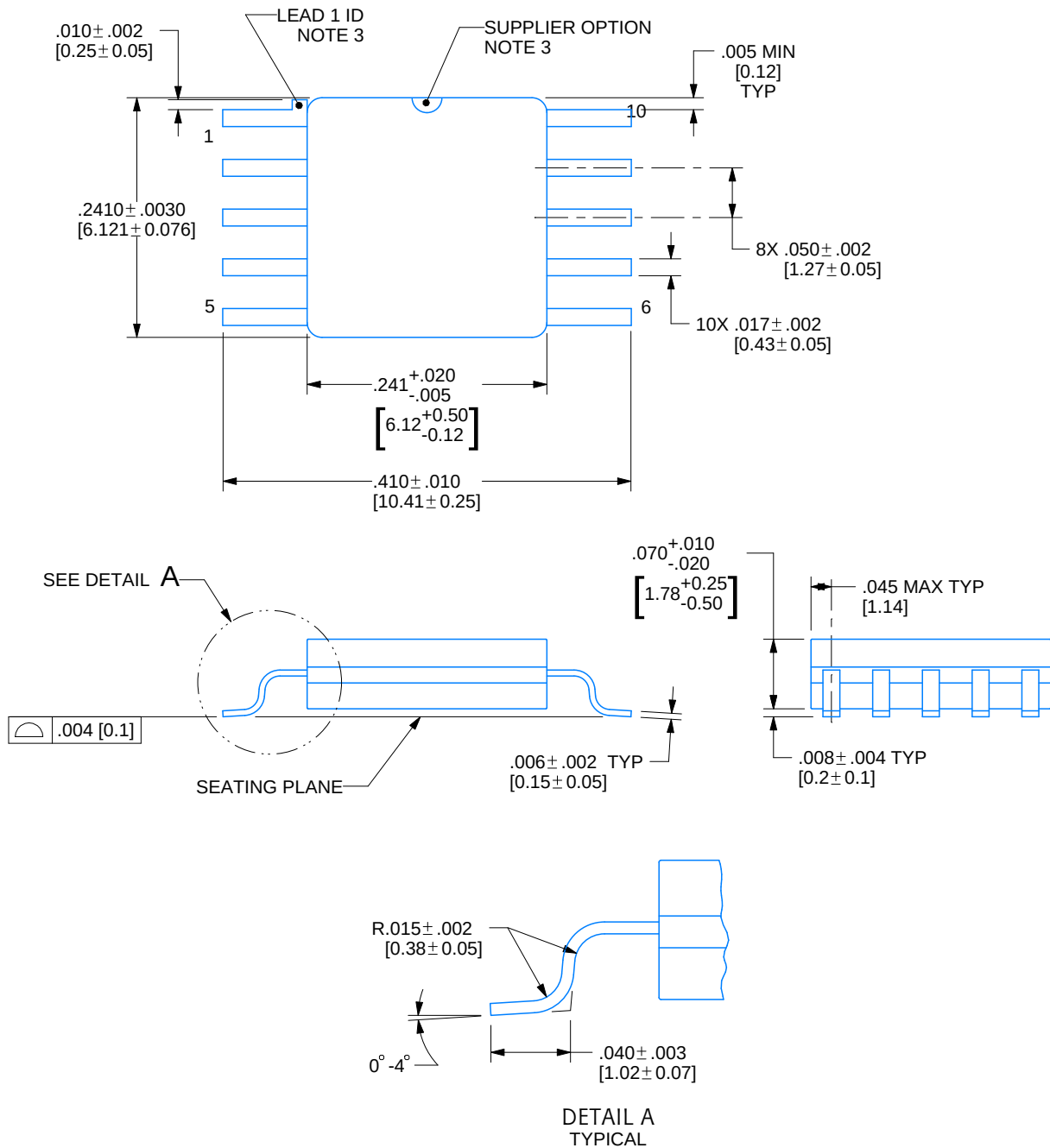


**NAC0010A**

**PACKAGE OUTLINE**

**CFP - 2.33mm max height**

CERAMIC FLATPACK



4215196/D 08/2022

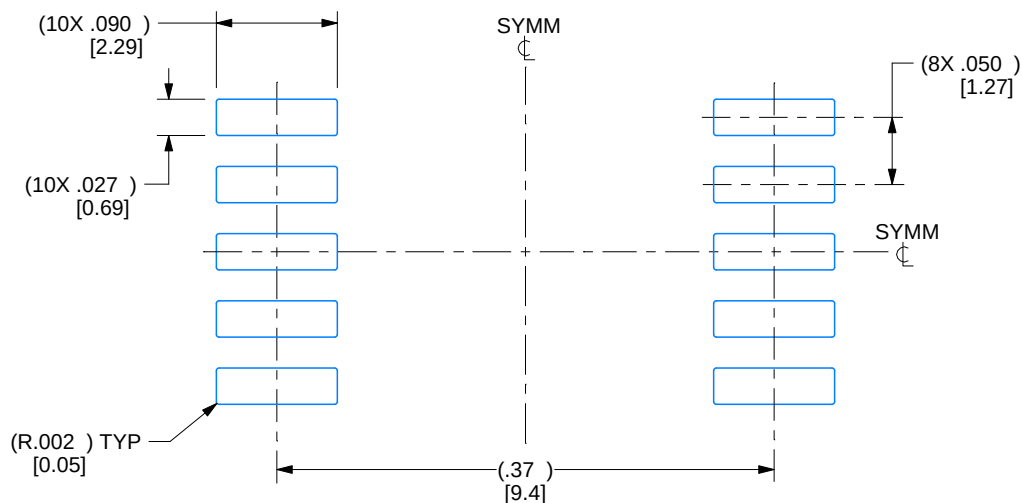
**NOTES:**

1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. For solder thickness and composition, see the "Lead Finish Composition/Thickness" link in the packaging section of the Texas Instruments website
3. Lead 1 identification shall be:
  - a) A notch or other mark within this area
  - b) A tab on lead 1, either side
4. No JEDEC registration as of December 2021

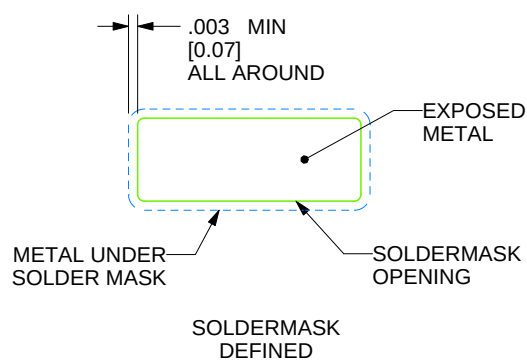
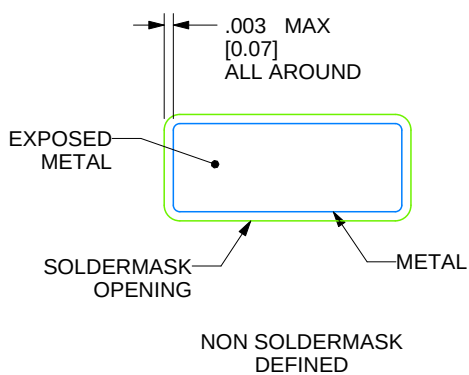
**NAC0010A**

**CFP - 2.33mm max height**

CERAMIC FLATPACK



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 7X



4215196/D 08/2022

REVISIONS

| REV | DESCRIPTION                                      | E.C.N.  | DATE       | BY/APP'D                |
|-----|--------------------------------------------------|---------|------------|-------------------------|
| A   | RELEASE TO DOCUMENT CONTROL                      | 2197877 | 12/30/2021 | DAVID CHIN / ANIS FAUZI |
| B   | NO CHANGE TO DRAWING; REVISION FOR YODA RELEASE; | 2198820 | 02/14/2022 | K. SINCERBOX            |
| C   | CHANGE PIN 1 ID LOCATION ON PIN                  | 2198845 | 02/18/2022 | D. CHIN / K. SINCERBOX  |
| D   | .2410± .0030 WAS .2700 +.0012/-.0002;            | 2200915 | 08/08/2022 | D. CHIN / K. SINCERBOX  |

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2025, Texas Instruments Incorporated