

NXP PCT2075 sensor datasheet

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PCT2075

I²C-bus Fm+, 1 degree C accuracy, digital temperature sensor and thermal watchdog

Rev. 7 — 6 March 2014

Product data sheet

1. General description

The PCT2075 is a temperature-to-digital converter featuring ± 1 °C accuracy over -25 °C to $+100$ °C range. It uses an on-chip band gap temperature sensor and Sigma-Delta A-to-D conversion technique with an overtemperature detection output that is a drop-in replacement for other LM75 series thermal sensors. The device contains a number of data registers: Configuration register (Conf) to store the device settings such as device operation mode, OS operation mode, OS polarity and OS fault queue; temperature register (Temp) to store the digital temp reading, set-point registers (Tos and Thyst) to store programmable overtemperature shutdown and hysteresis limits, and programmable temperature sensor sampling time Tidle, that can be communicated by a controller via the 2-wire serial I²C-bus Fast-mode Plus interface.

The PCT2075 also includes an open-drain output (OS) which becomes active when the temperature exceeds the programmed limits. The OS output operates in either of two selectable modes: OS comparator mode or OS interrupt mode. Its active state can be selected as either HIGH or LOW. The fault queue that defines the number of consecutive faults in order to activate the OS output is programmable as well as the set-point limits.

The PCT2075 can be configured for different operation conditions. It can be set in normal mode to periodically monitor the ambient temperature, or in shut-down mode to minimize power consumption.

The temperature register always stores an 11-bit two's complement data, giving a temperature resolution of 0.125 °C. This high temperature resolution is particularly useful in applications of measuring precisely the thermal drift or runaway. When the device is accessed the conversion in process is not interrupted (that is, the I²C-bus section is totally independent of the Sigma-Delta converter section) and accessing the device continuously without waiting at least one conversion time between communications will not prevent the device from updating the Temp register with a new conversion result. The new conversion result will be available immediately after the Temp register is updated. It is also possible to read just one of the temperature register bytes without lock-up.

The PCT2075 powers up in the normal operation mode with the OS in comparator mode, temperature threshold of 80 °C and hysteresis of 75 °C, so that it can be used as a stand-alone thermostat with those pre-defined temperature set points. The default set points can be modified during manufacture and ordered under custom part number.

There are three selectable logic address pins with three logic states so that 27 8-pin devices or three 6-pin devices can be connected on the same bus without address conflict.



2. Features and benefits

- Pin-for-pin replacement for LM75 series but allows up to 27 devices on the bus
- Power supply range from 2.7 V to 5.5 V
- Temperatures range from -55 °C to +125 °C
- Frequency range 20 kHz to 1 MHz with SMBus time-out to prevent hanging up the bus
- 1 MHz Fast-mode Plus 30 mA SDA drive allows more devices on the same bus but is backward compatible to Fast-mode and Standard-mode
- 11-bit ADC that offers a temperature resolution of 0.125 °C
- Temperature accuracy of:
 - ◆ ±1 °C (max.) from -25 °C to +100 °C
 - ◆ ±2 °C (max.) from -55 °C to +125 °C
- Programmable temperature threshold and hysteresis set points during operation
- Supply current of <1.0 µA in shut-down mode for power conservation
- Stand-alone operation as thermostat at power-up
- ESD protection exceeds 2000 V HBM per JESD22-A114 and 1000 V CDM per JESD22-C101
- Latch-up testing is done to JEDEC Standard JESD78 which exceeds 100 mA
- Small 8-pin package types: SO8, TSSOP8 and 2 mm × 3 mm HWSON8
- Small 6-pin package type: TSOP6

3. Applications

- System thermal management
- Personal computers
- Electronics equipment
- Industrial controllers

4. Ordering information

Table 1. Ordering information

| Type number | Topside mark | Package | | |
|-------------------------------|--------------|---------|--|-----------|
| | | Name | Description | Version |
| PCT2075D | PCT2075 | SO8 | plastic small outline package; 8 leads; body width 3.9 mm | SOT96-1 |
| PCT2075DP | P2075 | TSSOP8 | plastic thin shrink small outline package; 8 leads; body width 3 mm | SOT505-1 |
| PCT2075DP/Q900 ^[1] | P2075 | TSSOP8 | plastic thin shrink small outline package; 8 leads; body width 3 mm | SOT505-1 |
| PCT2075TP | 075 | HWSON8 | plastic thermal enhanced very very thin small outline package; no leads; 8 terminals, 2 × 3 × 0.8 mm | SOT1069-2 |
| PCT2075GV | 075 | TSOP6 | plastic thin small outline package; 6 leads | SOT1353-1 |

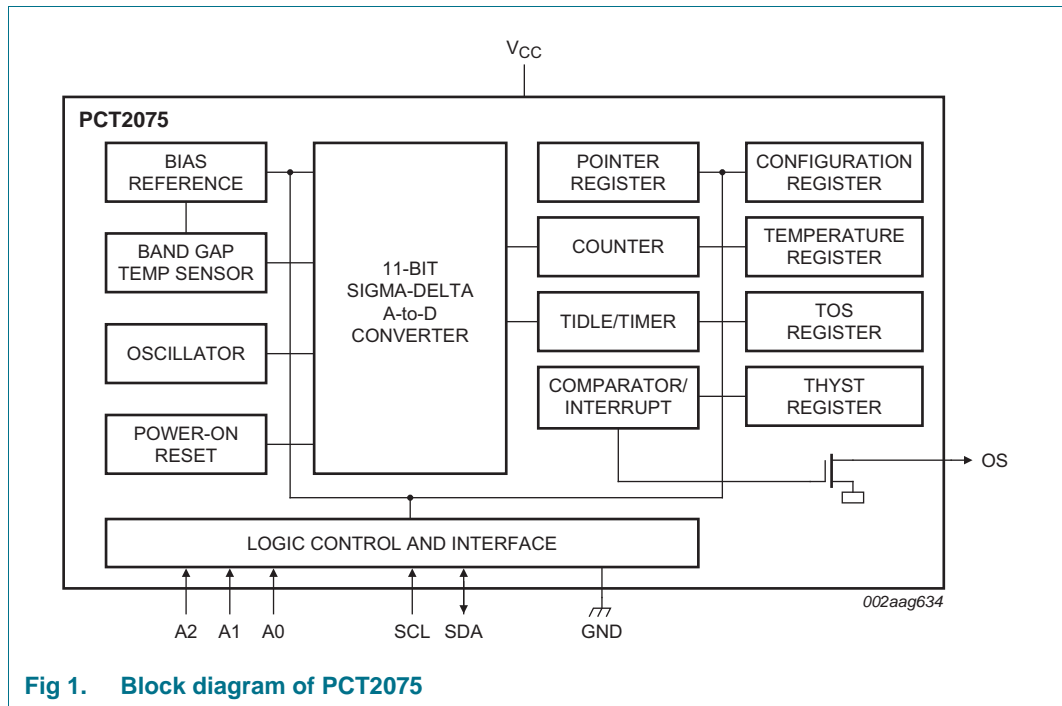
[1] PCT2075DP/Q900 is AEC-Q100 compliant. Contact i2c.support@nxp.com for PPAP.

4.1 Ordering options

Table 2. Ordering options

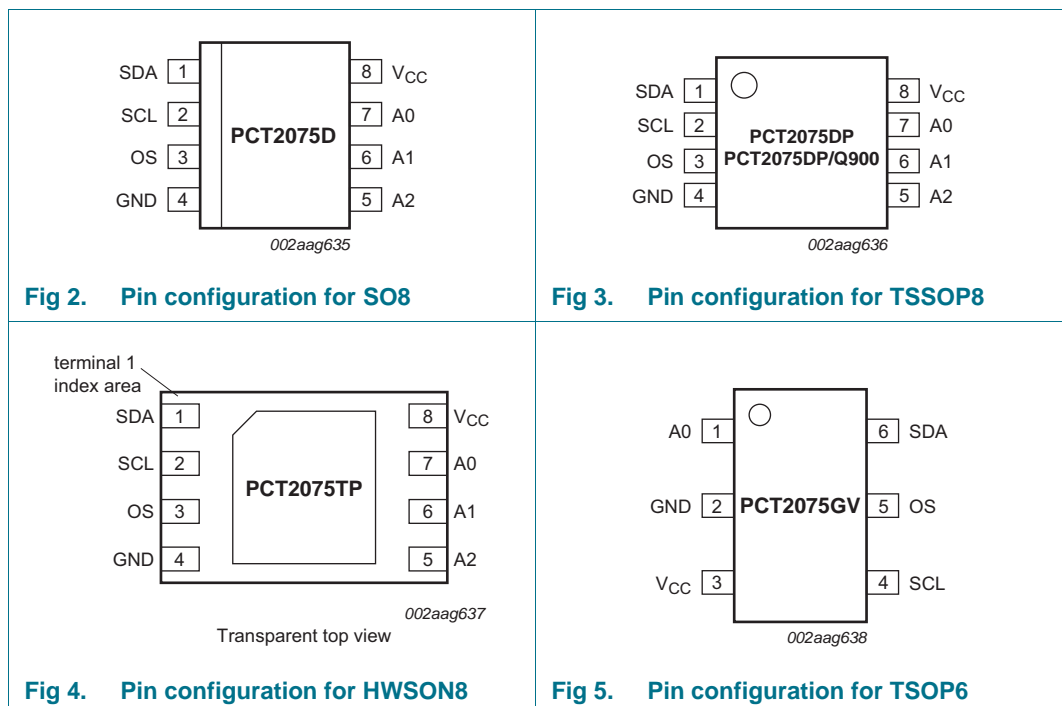
| Type number | Orderable part number | Package | Packing method | Minimum order quantity | Temperature |
|----------------|-----------------------|---------|--------------------------------------|------------------------|--------------------------------------|
| PCT2075D | PCT2075D,118 | SO8 | Reel 13" Q1/T1 *standard mark SMD | 2500 | T _{amb} = -55 °C to +125 °C |
| PCT2075DP | PCT2075DP,118 | TSSOP8 | Reel 13" Q1/T1 *standard mark SMD | 2500 | T _{amb} = -55 °C to +125 °C |
| PCT2075DP/Q900 | PCT2075DP/Q900J | TSSOP8 | Reel 13" Q1/T1 *standard mark SMD | 2500 | T _{amb} = -55 °C to +125 °C |
| PCT2075TP | PCT2075TP,147 | HWSON8 | Reel 7" Q2/T3 *standard mark | 4000 | T _{amb} = -55 °C to +125 °C |
| PCT2075GV | PCT2075GVH | TSOP6 | Reel 7" Q3/T4 *standard mark | 3000 | T _{amb} = -55 °C to +125 °C |

5. Block diagram



6. Pinning information

6.1 Pinning



6.2 Pin description

Table 3. Pin description for SO8, TSSOP8 and HWSO8

| Symbol | Pin | Description |
|-----------------|------------------|---|
| SDA | 1 | Digital I/O. I ² C-bus serial bidirectional data line; open-drain. |
| SCL | 2 | Digital input. I ² C-bus serial clock input. |
| OS | 3 | Overtemp Shutdown output; open-drain. |
| GND | 4 ^[1] | Ground. To be connected to the system ground. |
| A2 | 5 | Digital input. User-defined address bit 2. |
| A1 | 6 | Digital input. User-defined address bit 1. |
| A0 | 7 | Digital input. User-defined address bit 0. |
| V _{CC} | 8 | Power supply. |

[1] HWSO8 package die supply ground is connected to both the GND pin and the exposed center pad. The GND pin must be connected to supply ground for proper device operation. For enhanced thermal, electrical, and board-level performance, the exposed pad should be soldered to the board using a corresponding thermal pad on the board, and for proper heat conduction through the board thermal vias need to be incorporated in the PCB in the thermal pad region.

Table 4. Pin description for TSOP6

| Symbol | Pin | Description |
|-----------------|-----|---|
| A0 | 1 | Digital input. User-defined address bit 0. |
| GND | 2 | Ground. To be connected to the system ground. |
| V _{CC} | 3 | Power supply. |
| SCL | 4 | Digital input. I ² C-bus serial clock input. |
| OS | 5 | Overtemp Shutdown output; open-drain. |
| SDA | 6 | Digital I/O. I ² C-bus serial bidirectional data line; open-drain. |

7. Functional description

7.1 General operation

The PCT2075 uses the on-chip band gap sensor to measure the device temperature with the resolution of 0.125 °C and stores the 11-bit two's complement digital data, resulted from 11-bit A-to-D conversion, into the device Temp register. This Temp register can be read at any time by a controller on the I²C-bus. Reading temperature data does not affect the conversion in progress during the read operation.

The PCT2075 can be set to operate in either mode: normal or shutdown. In normal operation mode, the temp-to-digital conversion is executed every 100 ms or other programmed value and the Temp register is updated at the end of each conversion. During each 'conversion period' (T_{conv}) of about 100 ms, the device takes only about 28 ms, called 'temperature conversion time' ($t_{conv(T)}$), to complete a temperature-to-data conversion and then becomes idle for the time remaining in the period. This feature is implemented to significantly reduce the device power dissipation.

In shutdown mode, the device becomes idle, data conversion is disabled and the Temp register holds the latest result; however, the device I²C-bus interface is still active and register write/read operation can be performed. The device operation mode is controllable by programming bit B0 of the configuration register. The temperature conversion is initiated when the device is powered-up or put back into normal mode from shutdown.

In addition, at the end of each conversion in normal mode, the temperature data (or Temp) in the Temp register is automatically compared with the overtemperature shutdown threshold data (or T_{ots}) stored in the Tos register, and the hysteresis data (or T_{hys}) stored in the Thyst register, in order to set the state of the device OS output accordingly. The device Tos and Thyst registers are write/read capable, and both operate with 9-bit two's complement digital data. To match with this 9-bit operation, the Temp register uses only the 9 MSB bits of its 11-bit data for the comparison. T_{ots} must always be higher than T_{hys} .

The way that the OS output responds to the comparison operation depends upon the OS operation mode selected by configuration bit B1, and the user-defined fault queue defined by configuration bits B3 and B4.

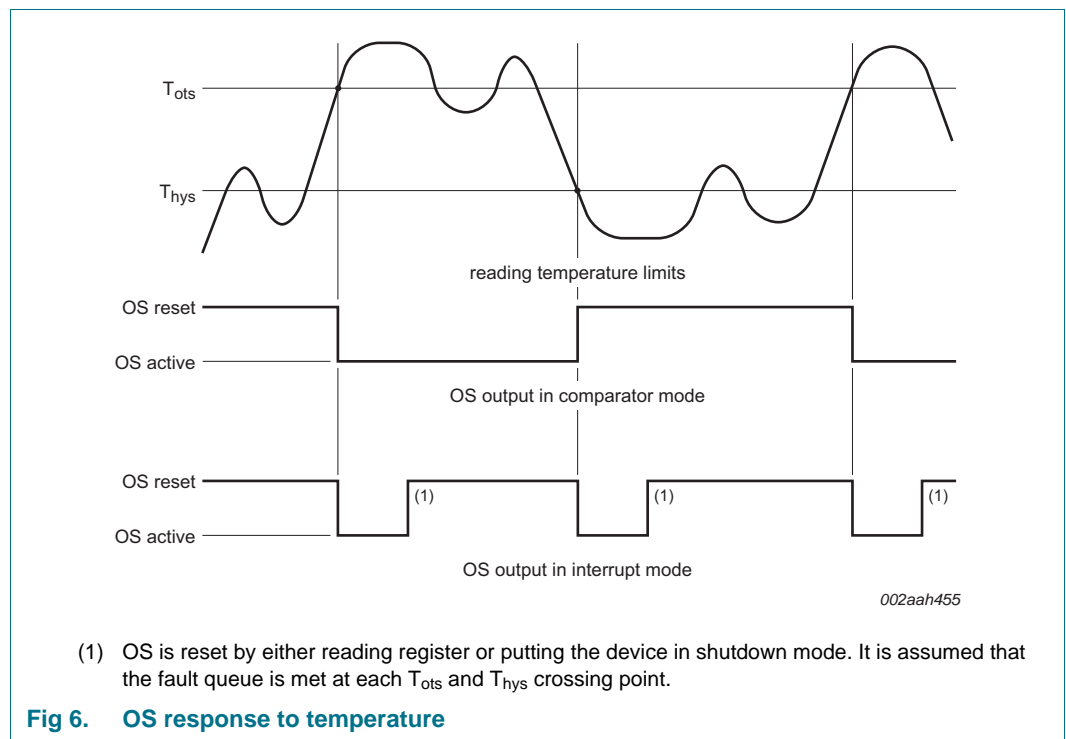
In OS comparator mode, the OS output behaves like a thermostat. It becomes active when the Temp exceeds the T_{ots} , and is reset when the Temp drops below the T_{hys} . Reading the device registers or putting the device into shutdown does not change the state of the OS output. The OS output in this case can be used to control cooling fans or thermal switches.

In OS interrupt mode, the OS output is used for thermal interruption. When the device is powered-up, the OS output is first activated only when the Temp exceeds the T_{ots} , then it remains active indefinitely until being reset by a read of any register. Once the OS output has been activated by crossing T_{ots} and then reset, it can be activated again only when the Temp drops below the T_{hys} ; then again, it remains active indefinitely until being reset by a read of any register. The OS interrupt operation would be continued in this sequence: T_{ots} trip, Reset, T_{hys} trip, Reset, T_{ots} trip, Reset, T_{hys} trip, Reset, etc. Putting the device into the shutdown mode by setting the bit 0 of the configuration register also resets the OS output.

In both cases, comparator mode and interrupt mode, the OS output is activated only if a number of consecutive faults, defined by the device fault queue, has been met. The fault queue is programmable and stored in the two bits, B3 and B4, of the Configuration register. Also, the OS output active state is selectable as HIGH or LOW by setting accordingly the configuration register bit B2.

At power-up, the PCT2075 is put into normal operation mode in OS comparator mode, the T_{ots} is set to 80 °C, the T_{hys} is set to 75 °C, the OS active state is selected LOW and the fault queue is equal to 1. The temp reading data is 0 °C and not updated until the first conversion is completed in about 28 ms. The default T_{ots} and T_{hys} is set at the factory and can be modified on custom part number.

The OS response to the temperature is illustrated in [Figure 6](#).



7.2 I²C-bus serial interface

The device can be connected to a compatible 2-wire serial interface Fast-mode Plus I²C-bus as a slave device under the control of a controller or master device, using two device terminals, SCL and SDA. The controller must provide the SCL clock signal and write/read data to/from the device through the SDA terminal. Notice that if the I²C-bus common pull-up resistors have not been installed as required for I²C-bus, then an external pull-up resistor, about 1.5 kΩ, is needed for each of these two terminals. The bus communication protocols are described in [Section 7.10](#).

7.2.1 Bus fault time-out

If the SDA line is held LOW for longer than t_{to} (25 ms minimum; guaranteed at 35 ms maximum), the device will reset to the idle state (SDA released) and wait for a new START condition. This ensures that the device will never hang up the bus should there be conflicts in the transmission sequence. The bus fault time-out can be disabled during manufacture and shipped under custom part number.

7.3 Slave address

To communicate with the device, the master must first address slave devices via a slave address byte. The slave address byte consists of seven address bits, and a direction bit indicating the intent of executing a read or write operation. The device features three address pins to allow up to 27 devices to be addressed on a single bus interface. [Table 5](#) describes the pin logic levels used to properly connect up to 27 8-pin devices. [Table 6](#) describes the pin logic levels used to properly connect up to three 6-pin devices. '1' indicates the pin is connected to the supply (V_{CC}); '0' indicates the pin is connected to GND; 'Float' indicates the pin is left unconnected. The states of pins A0/A1/A2 are sampled only at power-up. After sampling the address is latched to minimize power dissipation associated with detection.

Table 5. PCT2075 address table (SO8, TSSOP8, HWSON8 packages)

| No. | Address pin coding | | | Slave address |
|-----|--------------------|----------|----------|---------------|
| | A2 | A1 | A0 | |
| 1 | 0 | 0 | 0 | 1001 000 |
| 2 | 0 | 0 | 1 | 1001 001 |
| 3 | 0 | 1 | 0 | 1001 010 |
| 4 | 0 | 1 | 1 | 1001 011 |
| 5 | 1 | 0 | 0 | 1001 100 |
| 6 | 1 | 0 | 1 | 1001 101 |
| 7 | 1 | 1 | 0 | 1001 110 |
| 8 | 1 | 1 | 1 | 1001 111 |
| 9 | floating | 0 | 0 | 1110 000 |
| 10 | floating | 0 | floating | 1110 001 |
| 11 | floating | 0 | 1 | 1110 010 |
| 12 | floating | 1 | 0 | 1110 011 |
| 13 | floating | 1 | floating | 1110 100 |
| 14 | floating | 1 | 1 | 1110 101 |
| 15 | floating | floating | 0 | 1110 110 |
| 16 | floating | floating | 1 | 1110 111 |
| 17 | 0 | floating | 0 | 0101 000 |
| 18 | 0 | floating | 1 | 0101 001 |
| 19 | 1 | floating | 0 | 0101 010 |
| 20 | 1 | floating | 1 | 0101 011 |
| 21 | 0 | 0 | floating | 0101 100 |
| 22 | 0 | 1 | floating | 0101 101 |
| 23 | 1 | 0 | floating | 0101 110 |

Table 5. PCT2075 address table (SO8, TSSOP8, HWSO8 packages) ...continued

| No. | Address pin coding | | | Slave address |
|-----|--------------------|----------|----------|---------------|
| | A2 | A1 | A0 | |
| 24 | 1 | 1 | floating | 0101 111 |
| 25 | 0 | floating | floating | 0110 101 |
| 26 | 1 | floating | floating | 0110 110 |
| 27 | floating | floating | floating | 0110 111 |

Table 6. PCT2075 address table (TSOP6 package)

| No. | Address pin coding | Slave address |
|-----|--------------------|---------------|
| | A0 | |
| 1 | float | 1001 000 |
| 2 | 0 | 1001 001 |
| 3 | 1 | 1001 010 |

7.4 Register list

The PCT2075 contains four data registers beside the pointer register as listed in [Table 7](#). The pointer value, read/write capability and default content at power-up of the registers are also shown in [Table 7](#).

Table 7. Register table

| Register name | Pointer value | R/W | POR state | Description |
|---------------|---------------|-----------|-----------|---|
| Conf | 01h | R/W | 00h | Configuration register: contains a single 8-bit data byte; to set the device operating condition; default = 0. |
| Temp | 00h | read only | 0000h | Temperature register: contains two 8-bit data bytes; to store the measured Temp data. |
| Tos | 03h | R/W | 5000h | Overtemperature shutdown threshold register: contains two 8-bit data bytes; to store the overtemperature shutdown T_{ots} limit; default = 80 °C. |
| Thyst | 02h | R/W | 4B00h | Hysteresis register: contains two 8-bit data bytes; to store the hysteresis T_{hys} limit; default = 75 °C. |
| Tidle | 04h | R/W | 00h | Temperature conversion cycle default to 100 ms. |

7.4.1 Pointer register

The Pointer register contains an 8-bit data byte, of which the three LSB bits represent the pointer value of the other five registers, and the other five MSB bits are equal to 0, as shown in [Table 8](#) and [Table 9](#). The Pointer register is not accessible to the user, but is used to select the data register for write/read operation by including the pointer data byte in the bus command.

Table 8. Pointer register

| B7 | B6 | B5 | B4 | B3 | B[2:0] |
|----|----|----|----|----|---------------|
| 0 | 0 | 0 | 0 | 0 | pointer value |

Table 9. Pointer value

| B2 | B1 | B0 | Selected register |
|----|----|----|---|
| 0 | 0 | 0 | Temperature register (Temp) |
| 0 | 0 | 1 | Configuration register (Conf) |
| 0 | 1 | 0 | Hysteresis register (Thyst) |
| 0 | 1 | 1 | Overtemperature shutdown register (Tos) |
| 1 | 0 | 0 | Idle register (Tidle) |

Because the Pointer value is latched into the Pointer register when the bus command (which includes the pointer byte) is executed, a read from the device may or may not include the pointer byte in the statement. To read again a register that has been recently read and the pointer has been preset, the pointer byte does not have to be included. To read a register that is different from the one that has been recently read, the pointer byte must be included. However, a write to the device must always include the pointer byte in the statement. The bus communication protocols are described in [Section 7.10](#).

At power-up, the Pointer value is equal to 000b and the Temp register is selected; users can then read the Temp data without specifying the pointer byte.

Anything not shown in [Table 9](#) is reserved and should not be used.

7.4.2 Configuration register

The Configuration register (Conf) is a write/read register and contains an 8-bit non-complement data byte that is used to configure the device for different operation conditions. [Table 10](#) shows the bit assignments of this register.

Table 10. Conf register

Legend: * = default value.

| Bit | Symbol | Access | Value | Description |
|--------|---------------|--------|-------|---|
| B[7:5] | reserved | R/W | 000* | unused; any value written to these bits does not affect operation |
| B[4:3] | OS_F_QUE[1:0] | R/W | | OS fault queue programming |
| | | | 00* | queue value = 1 |
| | | | 01 | queue value = 2 |
| | | | 10 | queue value = 4 |
| | | | 11 | queue value = 6 |
| B2 | OS_POL | R/W | | OS polarity selection |
| | | | 0* | OS active LOW |
| | | | 1 | OS active HIGH |
| B1 | OS_COMP_INT | R/W | | OS operation mode selection |
| | | | 0* | OS comparator |
| | | | 1 | OS interrupt |
| B0 | SHUTDOWN | R/W | | device operation mode selection |
| | | | 0* | normal |
| | | | 1 | shutdown |

7.4.3 Temperature register

The Temperature register (Temp) holds the digital result of temperature measurement or monitor at the end of each analog-to-digital conversion. This register is read-only and contains two 8-bit data bytes consisting of one Most Significant Byte (MSByte) and one Least Significant Byte (LSByte). However, only 11 bits of those two bytes are used to store the Temp data in two's complement format with the resolution of 0.125 °C. [Table 11](#) shows the bit arrangement of the Temp data in the data bytes.

Table 11. Temp register

| MSByte | | | | | | | | LSByte | | | | | | | |
|--------|----|----|----|----|----|----|----|--------|----|----|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | X | X | X | X | X |

When reading register Temp, all 16 bits of the two data bytes (MSByte and LSByte) are provided to the bus and should be all collected by the controller for a valid temperature reading. However, only the 11 most significant bits should be used, and the five least significant bits of the LSByte are zero and should be ignored. One of the ways to calculate the Temp value in °C from the 11-bit Temp data is:

1. If the Temp data MSByte bit D10 = 0, then the temperature is positive and Temp value (°C) = +(Temp data) × 0.125 °C.
2. If the Temp data MSByte bit D10 = 1, then the temperature is negative and Temp value (°C) = -(two's complement of Temp data) × 0.125 °C.

Examples of the Temp data and value are shown in [Table 12](#).

Table 12. Temp register value

| 11-bit binary (two's complement) | Hexadecimal value | Decimal value | Value |
|----------------------------------|-------------------|---------------|-------------|
| 011 1111 1000 | 3F8 | 1016 | +127.000 °C |
| 011 1111 0111 | 3F7 | 1015 | +126.875 °C |
| 011 1111 0001 | 3F1 | 1009 | +126.125 °C |
| 011 1110 1000 | 3E8 | 1000 | +125.000 °C |
| 000 1100 1000 | 0C8 | 200 | +25.000 °C |
| 000 0000 0001 | 001 | 1 | +0.125 °C |
| 000 0000 0000 | 000 | 0 | 0.000 °C |
| 111 1111 1111 | 7FF | -1 | -0.125 °C |
| 111 0011 1000 | 738 | -200 | -25.000 °C |
| 110 0100 1001 | 649 | -439 | -54.875 °C |
| 110 0100 1000 | 648 | -440 | -55.000 °C |

For 9-bit Temp data application in replacing the industry standard LM75, just use only 9 MSB bits of the two bytes and disregard 7 LSB of the LSByte. The 9-bit Temp data with 0.5 °C resolution of the device is defined exactly in the same way as for the standard LM75 and it is here similar to the Tos and Thyst registers.

A single byte read (MSByte) of the Temp register is allowed. Then the temperature resolution will be 1.00 °C instead.

7.4.4 Overtemperature shutdown threshold (Tos) and hysteresis (Thyst) registers

These two registers, are write/read registers, and also called set-point registers. They are used to store the user-defined temperature limits, called overtemperature shutdown threshold (T_{ots}) and hysteresis temperature (T_{hys}), for the device watchdog operation. At the end of each conversion the Temp data will be compared with the data stored in these two registers in order to set the state of the device OS output; see [Section 7.1](#).

Each of the set-point registers contains two 8-bit data bytes consisting of one MSByte and one LSByte in the same format as the Temperature register. However, only 9 bits of the two bytes are used to store the set-point data in two's complement format with the resolution of 0.5 °C. [Table 13](#) and [Table 14](#) show the bit arrangement of the Tos data and Thyst data in the data bytes.

Notice that because only 9-bit data are used in the set-point registers, the device uses only the 9 MSB of the Temp data for data comparison.

Table 13. Tos register

| MSByte | | | | | | | | LSByte | | | | | | | |
|--------|----|----|----|----|----|----|----|--------|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | X | X | X | X | X | X | X |

Table 14. Thyst register

| MSByte | | | | | | | | LSByte | | | | | | | |
|--------|----|----|----|----|----|----|----|--------|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | X | X | X | X | X | X | X |

When a set-point register is read, all 16 bits are provided to the bus and must be collected by the controller for a valid temperature. However, only the 9 most significant bits should be used and the 7 LSB of the LSByte are equal to zero and should be ignored.

A single byte read of either Tos or Thyst is allowed.

Table 15 shows examples of the limit data and value.

Table 15. Tos and Thyst limit data and value

| 11-bit binary (two's complement) | Hexadecimal value | Decimal value | Value |
|----------------------------------|-------------------|---------------|-----------|
| 0 1111 1010 | 0FA | 250 | +125.0 °C |
| 0 0011 0010 | 032 | 50 | +25.0 °C |
| 0 0000 0001 | 001 | 1 | +0.5 °C |
| 0 0000 0000 | 000 | 0 | 0.0 °C |
| 1 1111 1111 | 1FF | -1 | -0.5 °C |
| 1 1100 1110 | 1CE | -50 | -25.0 °C |
| 1 1001 0010 | 192 | -110 | -55.0 °C |

7.4.5 Tidle register

For the device temperature sensor, the temperature is measured periodically to save power. When the temperature is being measured, the device burns approximately 70 µA active current. Since the ambient temperature changes slowly, it is unnecessary to let the temperature measurement continuously active. Instead, the device temperature sensor is set to idle for a user-specified time to save power after temperature measurement is done.

The Tidle register allows users to specify the sampling period to measure the temperature. The register is composed of 5-bit values TIDLE[4:0] at pointer address 04h. The values of TIDLE[7:5] are 'don't care' and have no effect on the temperature measurement period. The temperature measurement period can be calculated by TIDLE[4:0] × 100 ms. For example, if TIDLE[4:0] = 00001, the temperature sampling is '00001' × 100 ms = 100 ms. the temperature sensor allows a sampling period from 100 ms to 3.1 s by programming Tidle. If Tidle is set to '00000', it will be treated the same as Tidle = '00001' and the temperature sensor will measure temperature at 100 ms period.

Table 16. Tidle - Temperature idle register (address 04h) bit allocation

Temperature idle register contains the value of time in between temperature measurements. TIDLE[4:0] is the 5-bit Tidle value. Tidle × 100 ms is the temperature sampling period.

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|--------|---|---|---|----------|----------|----------|----------|----------|
| Symbol | - | - | - | TIDLE[4] | TIDLE[3] | TIDLE[2] | TIDLE[1] | TIDLE[0] |
| Reset | - | - | - | 0 | 0 | 0 | 0 | 1 |
| Access | - | - | - | R/W | R/W | R/W | R/W | R/W |

The device temperature sensor powers up to measure temperature every 100 ms, with Tidle = 00001 by default. For the PCT2075 with 11-bit accuracy, the ADC conversion is about 28 ms. As a result, the PCT2075 will be idle for (100 ms – 28 ms) = 72 ms between two temperature measurements.

7.5 OS output and polarity

The OS output is an open-drain output and its state represents results of the device watchdog operation as described in [Section 7.1](#). In order to observe this output state, an external pull-up resistor is needed. The resistor should be as large as possible, up to 1.5 kΩ, to minimize the Temp reading error due to internal heating by the high OS sinking current.

The OS output active state can be selected as HIGH or LOW by programming bit B2 (OS_POL) of register Conf: setting bit OS_POL to logic 1 selects OS active HIGH and setting bit B2 to logic 0 sets OS active LOW. At power-up, bit OS_POL is equal to logic 0 and the OS active state is LOW.

7.6 OS comparator and interrupt modes

As described in [Section 7.1](#), the device OS output responds to the result of the comparison between register Temp data and the programmed limits, in registers Tos and Thyst, in different ways depending on the selected OS mode: OS comparator or OS interrupt. The OS mode is selected by programming bit B1 (OS_COMP_INT) of register Conf: setting bit OS_COMP_INT to logic 1 selects the OS interrupt mode, and setting to logic 0 selects the OS comparator mode. At power-up, bit OS_COMP_INT is equal to logic 0 and the OS comparator is selected.

The main difference between the two modes is that in OS comparator mode, the OS output becomes active when Temp has exceeded T_{ots} and reset when Temp has dropped below T_{hys}, reading a register or putting the device into shutdown mode does not change the state of the OS output; while in OS interrupt mode, once it has been activated either by exceeding T_{ots} or dropping below T_{hys}, the OS output will remain active indefinitely until reading a register, then the OS output is reset.

Temperature limits T_{ots} and T_{hys} must be selected so that T_{ots} > T_{hys}. Otherwise, the OS output state will be undefined.

7.7 OS fault queue

Fault queue is defined as the number of faults that must occur consecutively to activate the OS output. It is provided to avoid false tripping due to noise. Because faults are determined at the end of data conversions, fault queue is also defined as the number of consecutive conversions returning a temperature trip. The value of fault queue is selectable by programming the two bits B4 and B3 (OS_F_QUE[1:0]) in register Conf. Notice that the programmed data and the fault queue value are not the same. [Table 17](#) shows the one-to-one relationship between them. At power-up, fault queue data = 0 and fault queue value = 1.

Table 17. Fault queue table

| Fault queue data | | Fault queue value |
|------------------|-------------|-------------------|
| OS_F_QUE[1] | OS_F_QUE[0] | Decimal |
| 0 | 0 | 1 |
| 0 | 1 | 2 |
| 1 | 0 | 4 |
| 1 | 1 | 6 |

7.8 Shutdown mode

The device operation mode is selected by programming bit B0 (SHUTDOWN) of register Conf. Setting bit SHUTDOWN to logic 1 will put the device into shutdown mode. Resetting bit SHUTDOWN to logic 0 will return the device to normal mode.

In shutdown mode, the PCT2075 draws a small current of <1.0 μ A and the power dissipation is minimized; the temperature conversion stops, but the I²C-bus interface remains active and register write/read operation can be performed. When the shutdown is set, the OS output will be unchanged in comparator mode and reset in interrupt mode.

7.9 Power-up default and power-on reset

The PCT2075 always powers-up in its default state with:

- Normal operation mode
- OS comparator mode
- $T_{ots} = 80$ °C (or as specified for the custom part number)
- $T_{hys} = 75$ °C (or as specified for the custom part number)
- OS output active state is LOW
- Pointer value is logic 000 (Temp)
- SMBus time-out enabled (or as specified for the custom part number)

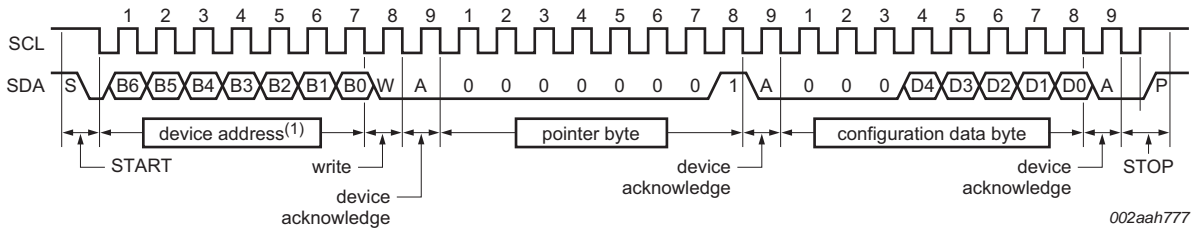
When the power supply voltage is dropped below the device power-on reset level of approximately 1.0 V (POR) for over 2 μ s and then rises up again, the PCT2075 will be reset to its default condition as listed above.

In some applications a higher or lower default T_{ots} and T_{hys} values or no SMBus time-out may be required. Please contact NXP for information on custom part number.

7.10 Protocols for writing and reading the registers

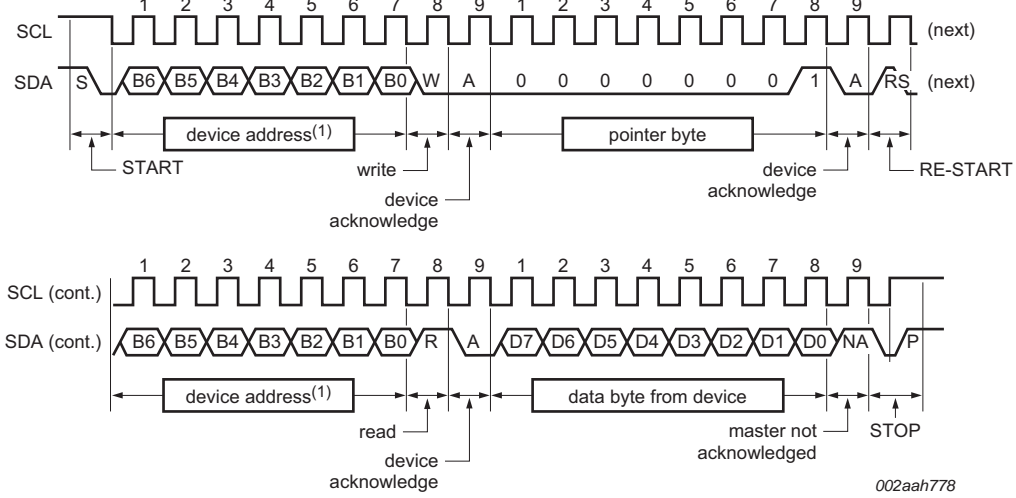
The communication between the host and the device must strictly follow the rules as defined by the I²C-bus management. The protocols for device register read/write operations are illustrated in [Figure 7](#) to [Figure 12](#) together with the following definitions:

1. Before a communication, the I²C-bus must be free or not busy. It means that the SCL and SDA lines must both be released by all devices on the bus, and they become HIGH by the bus pull-up resistors.
2. The host must provide SCL clock pulses necessary for the communication. Data is transferred in a sequence of 9 SCL clock pulses for every 8-bit data byte followed by 1-bit status of the acknowledgement.
3. During data transfer, except the START and STOP signals, the SDA signal must be stable while the SCL signal is HIGH. It means that the SDA signal can be changed only during the LOW duration of the SCL line.
4. S: START signal, initiated by the host to start a communication, the SDA goes from HIGH to LOW while the SCL is HIGH.
5. RS: RE-START signal, same as the START signal, to start a read command that follows a write command.
6. P: STOP signal, generated by the host to stop a communication, the SDA goes from LOW to HIGH while the SCL is HIGH. The bus becomes free thereafter.
7. W: write bit, when the write/read bit = LOW in a write command.
8. R: read bit, when the write/read bit = HIGH in a read command.
9. A: device acknowledge bit, returned by the device. It is LOW if the device works properly and HIGH if not. The host must release the SDA line during this period in order to give the device the control on the SDA line.
10. A': master acknowledge bit, not returned by the device, but set by the master or host in reading 2-byte data. During this clock period, the host must set the SDA line to LOW in order to notify the device that the first byte has been read for the device to provide the second byte onto the bus.
11. NA: Not Acknowledge bit. During this clock period, both the device and host release the SDA line at the end of a data transfer, the host is then enabled to generate the STOP signal.
12. In a write protocol, data is sent from the host to the device and the host controls the SDA line, except during the clock period when the device sends the device acknowledgement signal to the bus.
13. In a read protocol, data is sent to the bus by the device and the host must release the SDA line during the time that the device is providing data onto the bus and controlling the SDA line, except during the clock period when the master sends the master acknowledgement signal to the bus.
14. For best temperature accuracy both temperature bytes should be read as shown in [Figure 11](#) and [Figure 12](#), but for a quick less accurate check/reduce bus transmission then only one byte, the MSByte, needs to be read as shown in [Figure 9](#).



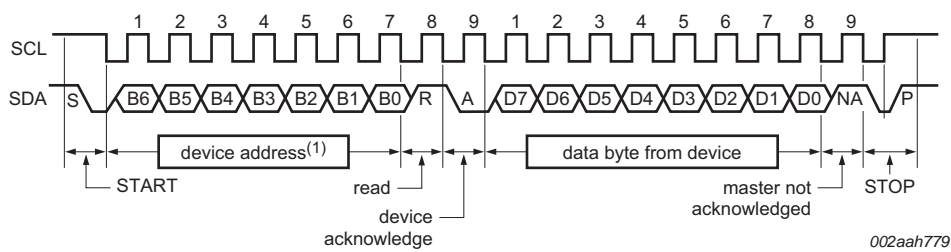
(1) See [Table 5](#) or [Table 6](#) for device address.

Fig 7. Write configuration register (1-byte data)



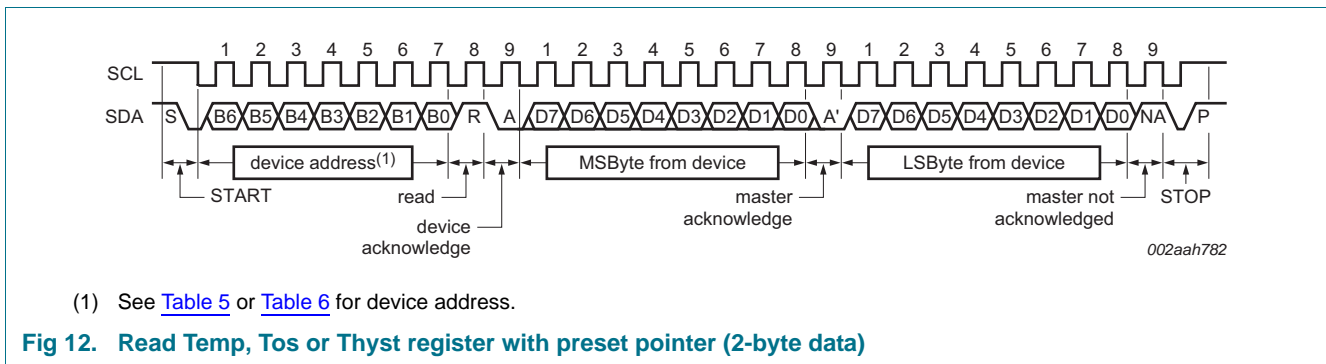
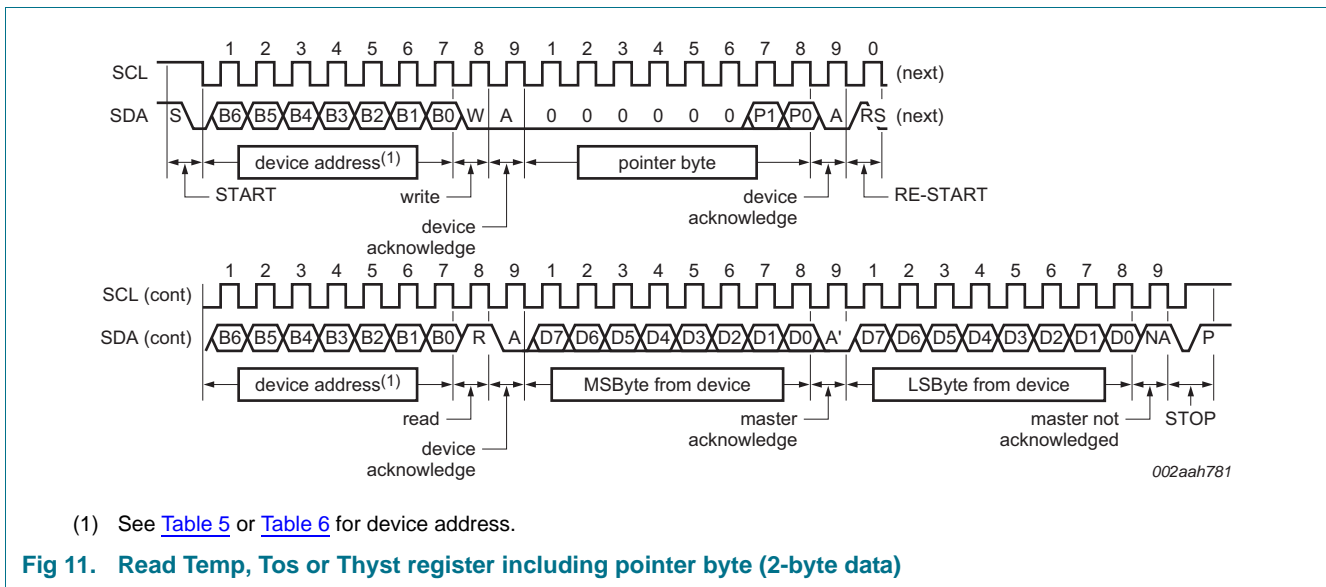
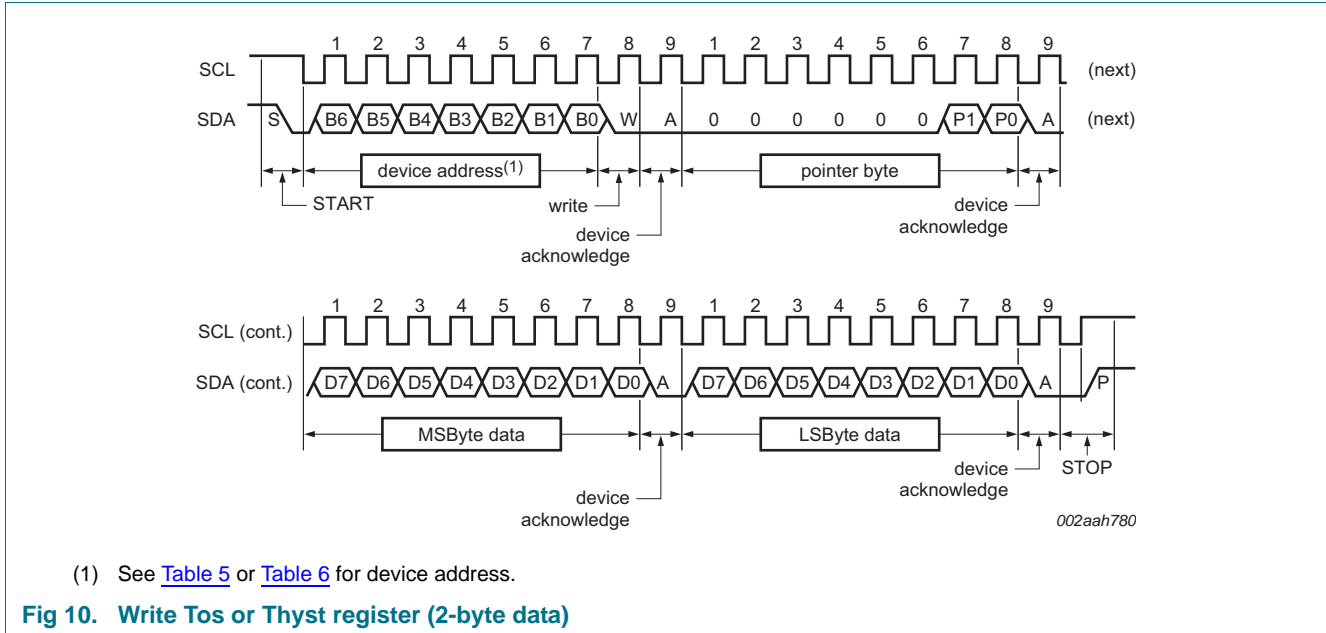
(1) See [Table 5](#) or [Table 6](#) for device address.

Fig 8. Read configuration register including pointer byte (1-byte data)



(1) See [Table 5](#) or [Table 6](#) for device address.

Fig 9. Read configuration or temp register with preset pointer (1-byte data)



8. Application design-in information

8.1 Typical application

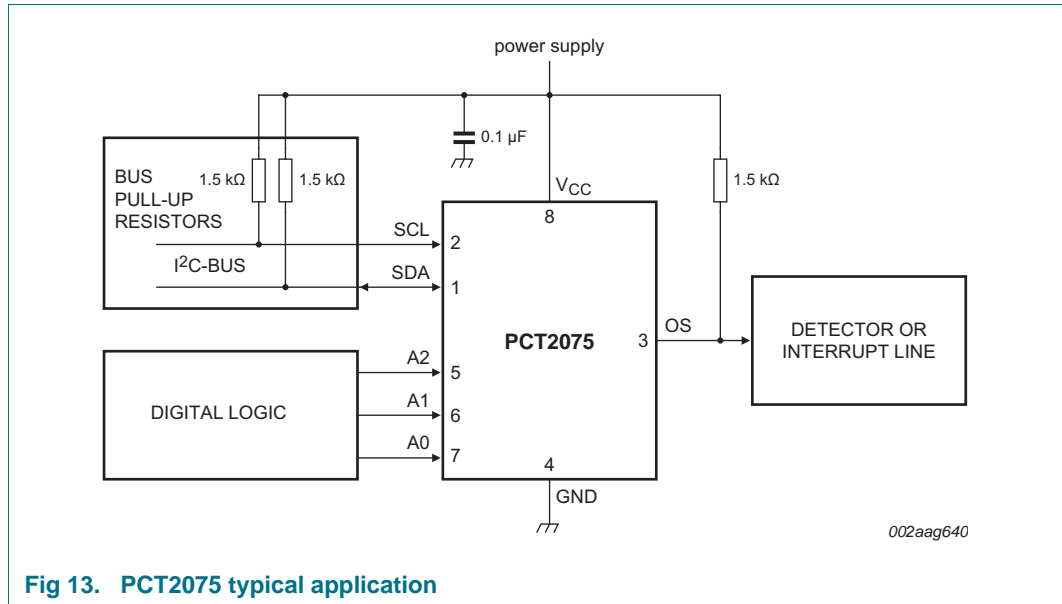


Fig 13. PCT2075 typical application

8.2 Temperature accuracy

Because the local channel of the temperature sensor measures its own die temperature that is transferred from its body, the temperature of the device body must be stabilized and saturated for it to provide the stable readings. Because the device operates at a low-power level, the thermal gradient of the device package has a minor effect on the measurement. The accuracy of the measurement is more dependent upon the definition of the environment temperature, which is affected by different factors: the printed-circuit board on which the device is mounted; the air flow contacting the device body (if the ambient air temperature and the printed-circuit board temperature are much different, then the measurement may not be stable because of the different thermal paths between the die and the environment). The stabilized temperature liquid of a thermal bath will provide the best temperature environment when the device is completely dipped into it. A thermal probe with the device mounted inside a sealed-end metal tube located in consistent temperature air also provides a good method of temperature measurement.

8.3 Noise effect

The device design includes the implementation of basic features for a good noise immunity:

- The 50 ns low-pass filter on both the bus pins SCL and SDA;
- The hysteresis of the threshold voltages to the bus input signals SCL and SDA, about 500 mV minimum;
- All pins have ESD protection circuitry to prevent damage during electrical surges. The ESD protection on the address, OS, SCL and SDA pins it to ground. The latch-back based device breakdown voltage of address/OS is typically 11 V and SCL/SDA is typically 9.5 V at any supply voltage but will vary over process and temperature. Since

there are no protection diodes from SCL or SDA to V_{CC} , the device will not hold the I²C lines LOW when V_{CC} is not supplied and therefore allow continued I²C-bus operation if the device is de-powered.

However, good layout practices and extra noise filters are recommended when the device is used in a very noisy environment:

- Use decoupling capacitors at V_{CC} pin.
- Keep the digital traces away from switching power supplies.
- Apply proper terminations for the long board traces.
- Add capacitors to the SCL and SDA lines to increase the low-pass filter characteristics.

9. Limiting values

Table 18. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol | Parameter | Conditions | Min | Max | Unit |
|---------------|----------------------|---------------|------|------|------|
| V_{CC} | supply voltage | | -0.3 | +6.0 | V |
| V_I | input voltage | at input pins | -0.3 | +6.0 | V |
| I_I | input current | at input pins | -5.0 | +5.0 | mA |
| $I_{O(sink)}$ | output sink current | on pin OS | - | 60 | mA |
| V_O | output voltage | on pin OS | -0.3 | +6.0 | V |
| T_{stg} | storage temperature | | -65 | +150 | °C |
| T_j | junction temperature | | - | 150 | °C |

10. Recommended operating conditions

Table 19. Recommended operating characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------|---------------------|------------|-----|-----|------|------|
| V_{CC} | supply voltage | | 2.7 | - | 5.5 | V |
| T_{amb} | ambient temperature | | -55 | - | +125 | °C |

11. Static characteristics

Table 20. Static characteristics
 $V_{CC} = 2.7\text{ V to }5.5\text{ V}$; $T_{amb} = -55\text{ °C to }+125\text{ °C}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ ^[1] | Max | Unit |
|----------------------|--------------------------------------|--|-----------------------|--------------------|-----------------------|------|
| T _{acc} | temperature accuracy | T _{amb} = -25 °C to +100 °C | -1 | - | +1 | °C |
| | | T _{amb} = -55 °C to +125 °C | -2 | - | +2 | °C |
| T _{res} | temperature resolution | 11-bit digital temp data | - | 0.125 | - | °C |
| t _{conv(T)} | temperature conversion time | normal mode | - | 28 | - | ms |
| T _{conv} | conversion period | normal mode | - | 0.1 | 3.2 | s |
| V _{POR} | power-on reset voltage | | - | - | 2.6 | V |
| I _{CC(AV)} | average supply current | normal mode: I ² C-bus inactive | - | 125 | 300 | μA |
| | | normal mode: I ² C-bus active; f _{SCL} = 1000 kHz | - | 200 | 400 | μA |
| | | shutdown mode | | | | |
| | | T _{amb} = 25 °C | - | <0.1 | - | μA |
| | | T _{amb} = 85 °C | - | <1 | - | μA |
| I _{IH} | HIGH-level input current | T _{amb} = 125 °C | - | - | 20 | μA |
| | | digital pins (SCL, SDA, A2 to A0) | 0.7 × V _{CC} | - | V _{CC} + 0.3 | V |
| | | digital pins | -0.3 | - | 0.3 × V _{CC} | V |
| V _{I(hys)} | hysteresis of input voltage | SCL and SDA pins | - | 300 | - | mV |
| | | A2, A1, A0 pins | - | 150 | - | mV |
| I _{IH} | HIGH-level input current | digital pins; V _I = V _{CC} | | | | |
| | | T _{amb} = 25 °C | - | <0.1 | - | μA |
| | | T _{amb} = 85 °C (PCT2075D, DP and TP only) | - | <1 | - | μA |
| | | T _{amb} = 85 °C (PCT2075GV only) | - | <2 | - | μA |
| | | T _{amb} = 125 °C (PCT2075D, DP and TP only) | - | - | 10 | μA |
| I _{LO} | output leakage current | SDA and OS pins; V _{OH} = V _{CC} | - | - | 20 | μA |
| | | digital pins; V _I = 0 V | -1.0 | - | +1.0 | μA |
| V _{OL} | LOW-level output voltage | OS pin; I _{OL} = 20 mA | - | - | 0.4 | V |
| | | SDA pin; I _{OL} = 20 mA | - | - | 0.4 | V |
| N _{fault} | number of faults | programmable; conversions in overtemperature-shutdown fault queue | 1 | - | 6 | |
| T _{ots} | overtemperature shutdown temperature | default value | - | 80 | - | °C |
| T _{hys} | hysteresis temperature | default value | - | 75 | - | °C |
| C _i | input capacitance | digital pins | - | 20 | - | pF |

[1] Typical values are at V_{CC} = 3.3 V and T_{amb} = 25 °C.

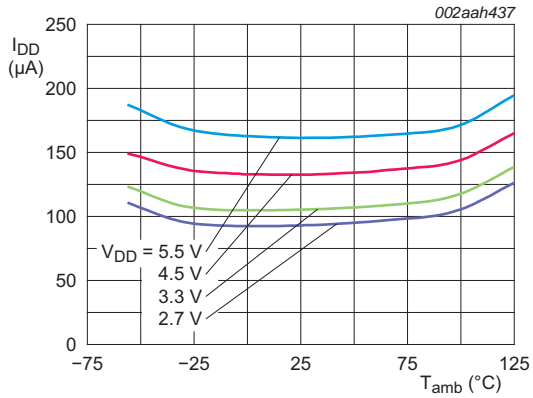


Fig 14. Average supply current versus temperature; I²C-bus inactive

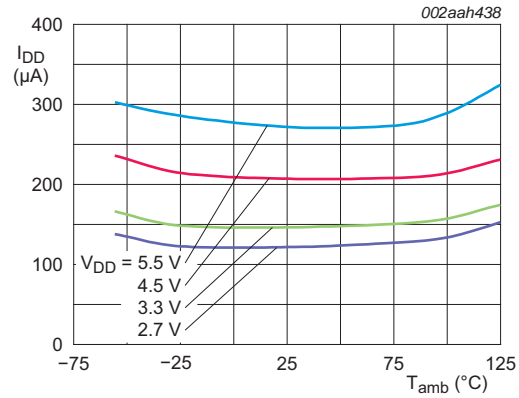


Fig 15. Average supply current versus temperature; I²C-bus active

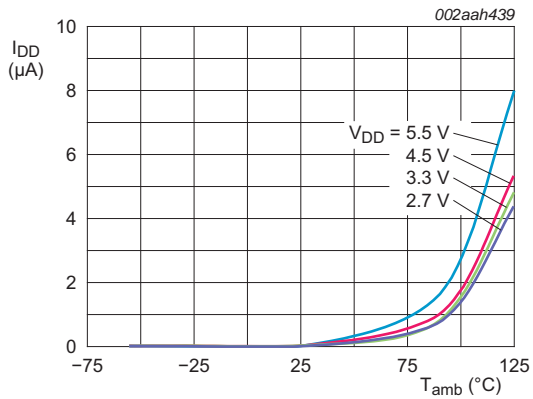


Fig 16. Shutdown mode supply current versus temperature

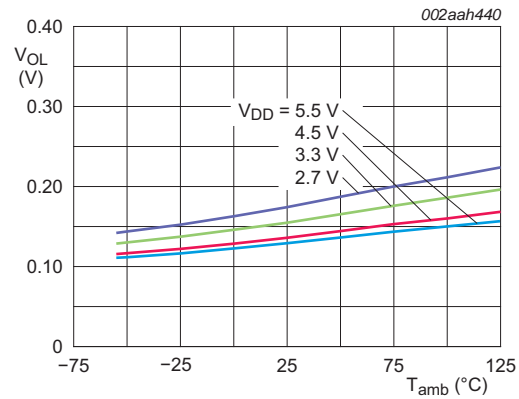


Fig 17. LOW-level output voltage on OS pin versus temperature; I_{OL} = 4 mA

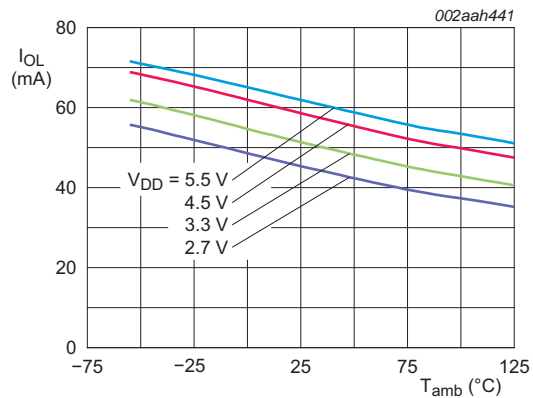


Fig 18. LOW-level output current on OS pin versus temperature; V_{OL} = 0.4 V

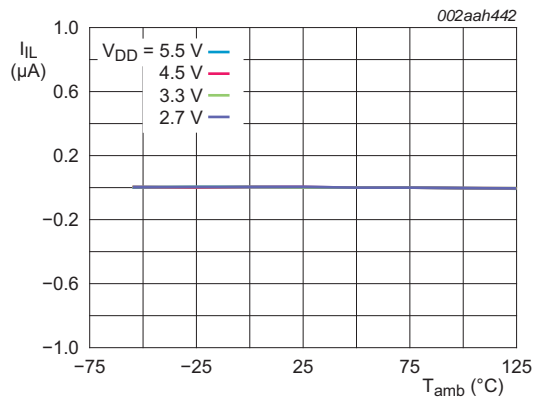


Fig 19. LOW-level input current versus temperature; digital pins

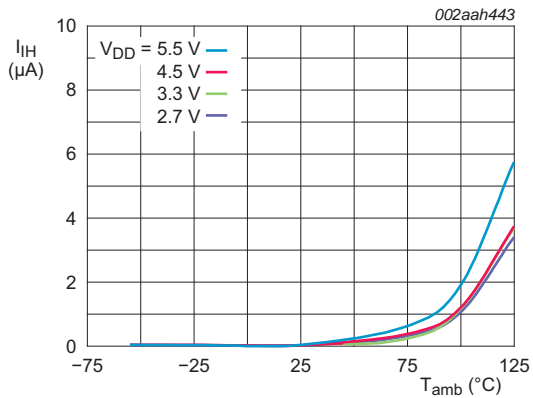


Fig 20. HIGH-level input current versus temperature; digital pins

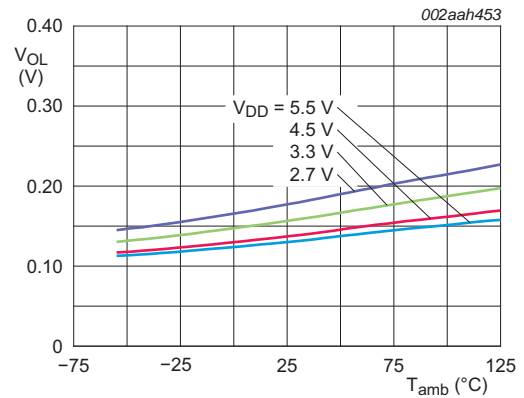


Fig 21. LOW-level output voltage on SDA pin versus temperature; I_{OL} = 20 mA

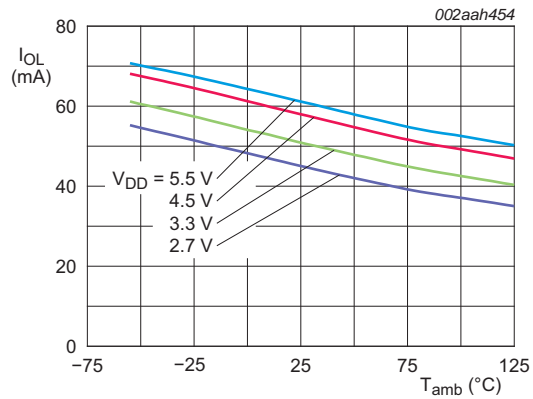


Fig 22. LOW-level output current on SDA pin versus temperature; V_{OL} = 0.4 V

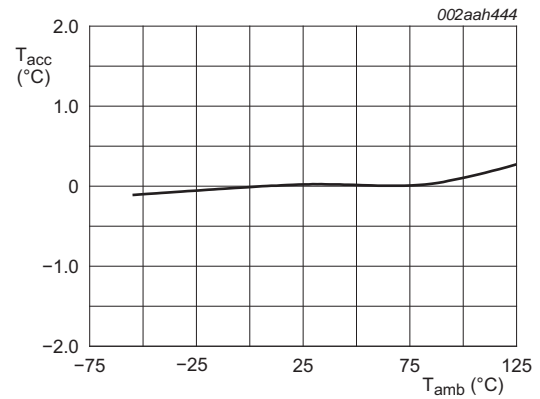


Fig 23. Temperature accuracy versus temperature; V_{CC} = 2.8 V to 5.5 V

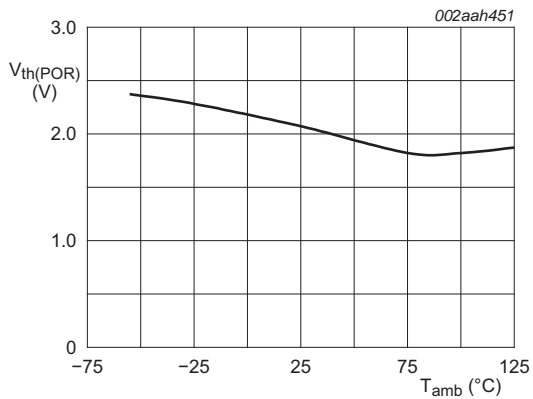


Fig 24. Power-on reset threshold voltage versus temperature; rising V_{CC}

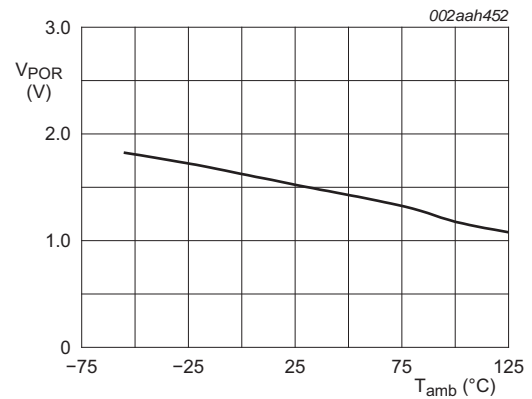


Fig 25. Power-on reset voltage versus temperature; falling V_{CC}

12. Dynamic characteristics

Table 21. I²C-bus interface dynamic characteristics^[1]

$V_{CC} = 2.7\text{ V to }5.5\text{ V}$; $T_{amb} = -55\text{ }^{\circ}\text{C to }+125\text{ }^{\circ}\text{C}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------------|--------------------------------------|--|---|-----|------|---------------|
| f_{SCL} | SCL clock frequency | see Figure 26 | 20 | - | 1000 | kHz |
| t_{HIGH} | HIGH period of the SCL clock | | 0.26 | - | - | μs |
| t_{LOW} | LOW period of the SCL clock | | 0.5 | - | - | μs |
| $t_{HD;STA}$ | hold time (repeated) START condition | | 0.26 | - | - | μs |
| $t_{SU;DAT}$ | data set-up time | | 50 | - | - | ns |
| $t_{HD;DAT}$ | data hold time | | 0 | - | - | ns |
| $t_{SU;STO}$ | set-up time for STOP condition | | 0.26 | - | - | μs |
| t_f | fall time | SDA and OS outputs; $C_L = 450\text{ pF}$; $I_{OL} = 30\text{ mA}$ | - | 120 | - | ns |
| $t_{to(SMBus)}$ | SMBus time-out time | | [2] [3] | - | 35 | ms |

- [1] These specifications are guaranteed by design and not tested in production.
- [2] This is the SDA time LOW for reset of serial interface.
- [3] Holding the SDA line LOW for a time greater than t_{to} will cause the device to reset SDA to the idle state of the serial bus communication (SDA set HIGH).

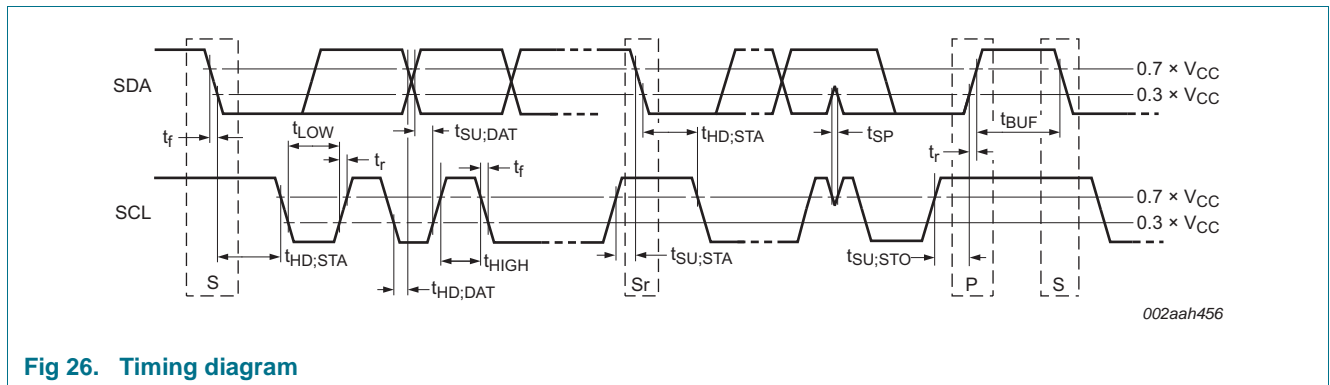


Fig 26. Timing diagram

13. Package outline

SO8: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1

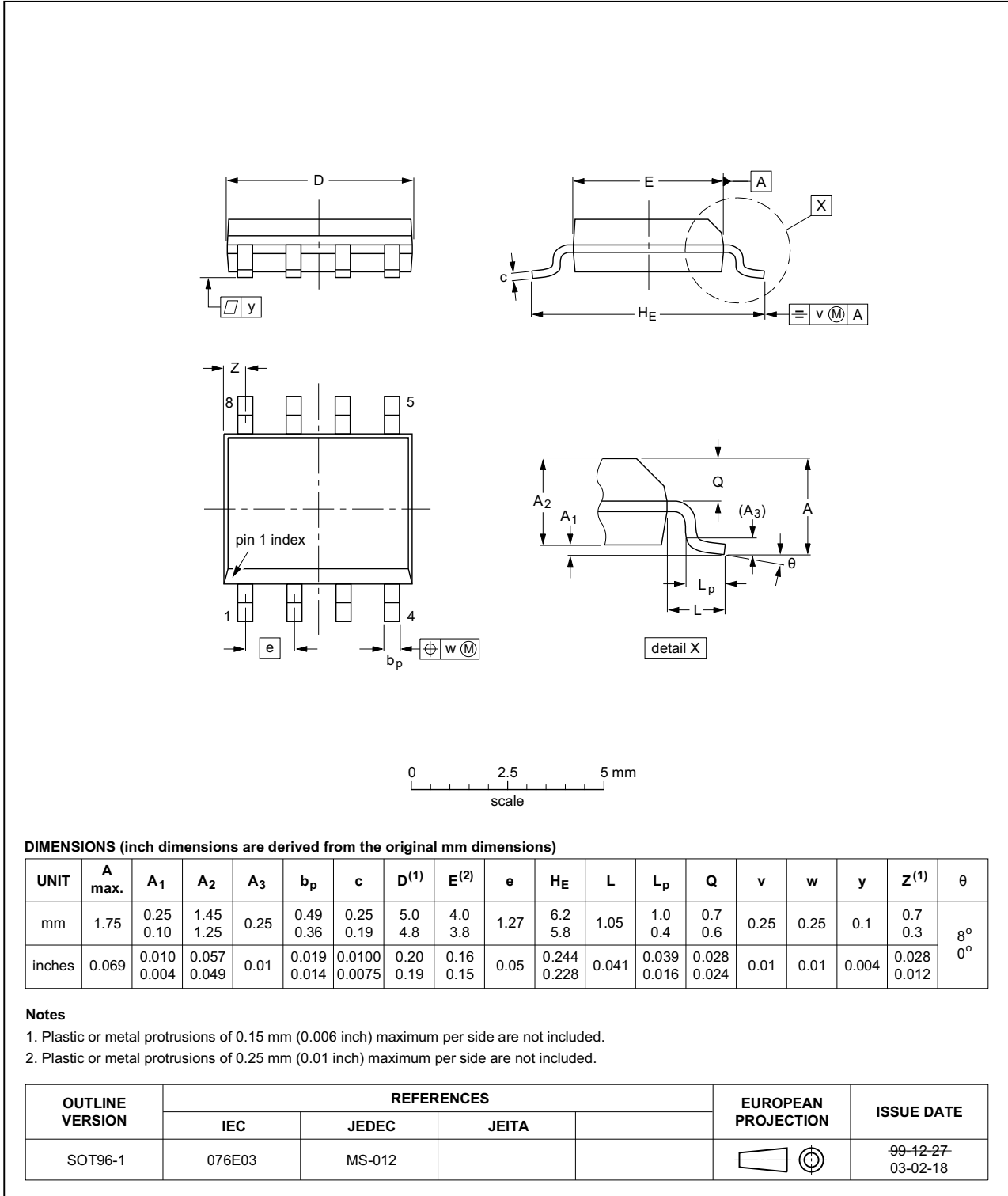


Fig 27. Package outline SOT96-1 (SO8)

TSSOP8: plastic thin shrink small outline package; 8 leads; body width 3 mm

SOT505-1

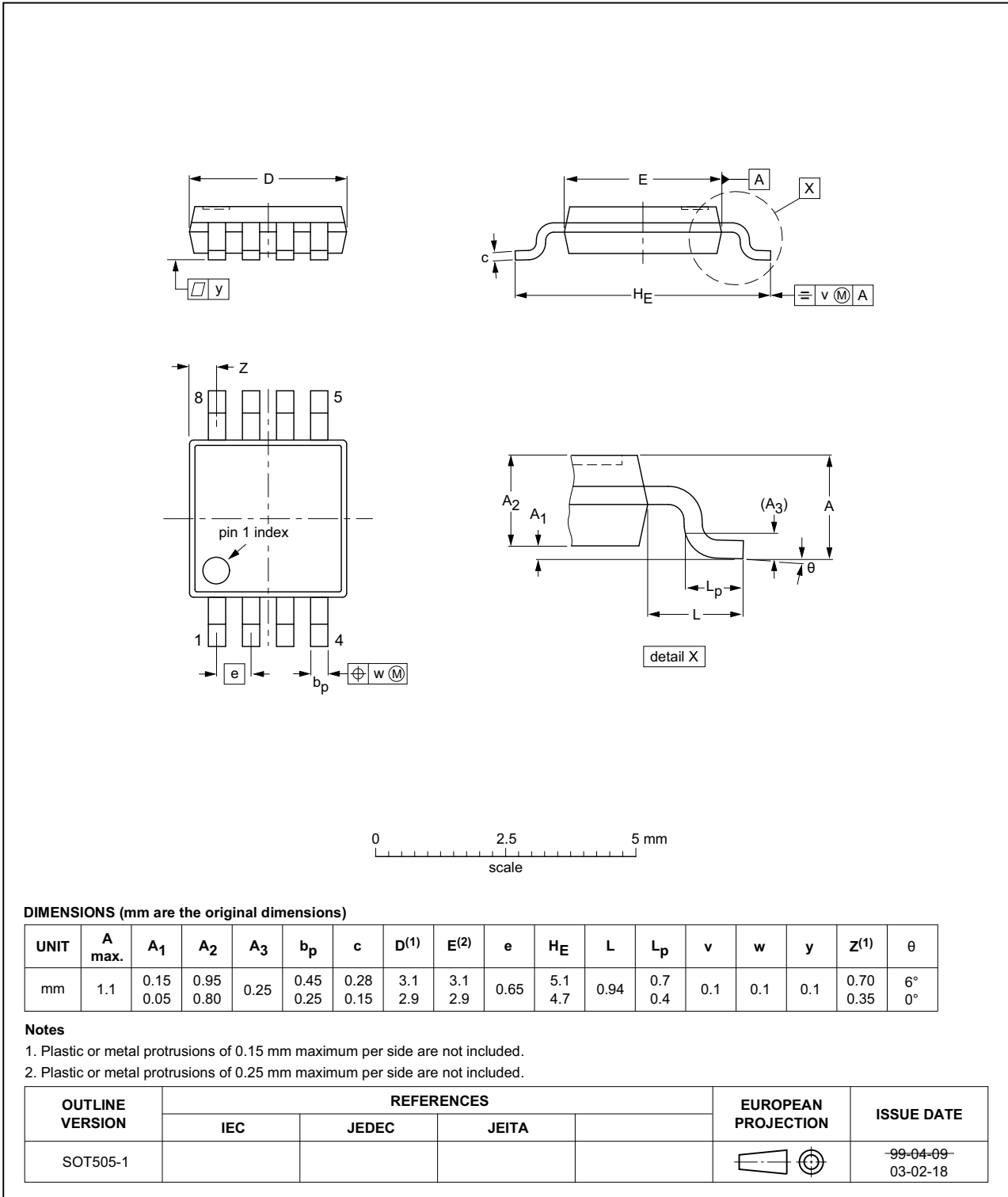


Fig 28. Package outline SOT505-1 (TSSOP8)

HWSON8: plastic thermal enhanced very very thin small outline package; no leads;
8 terminals; body 2 x 3 x 0.75 mm

SOT1069-2

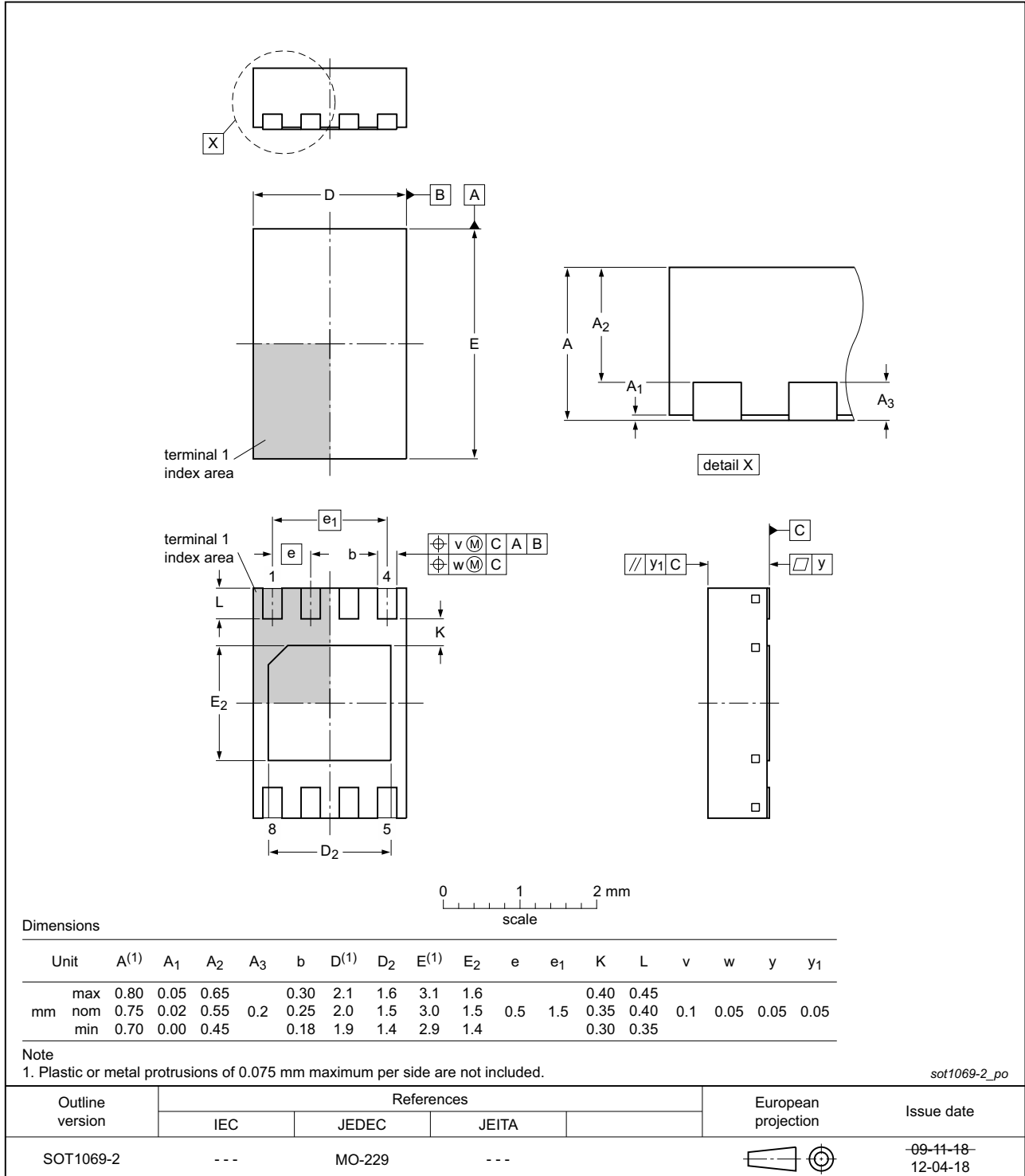


Fig 29. Package outline SOT1069-2 (HWSON8)

TSOP6: Plastic thin small outline package; 6 leads

SOT1353-1

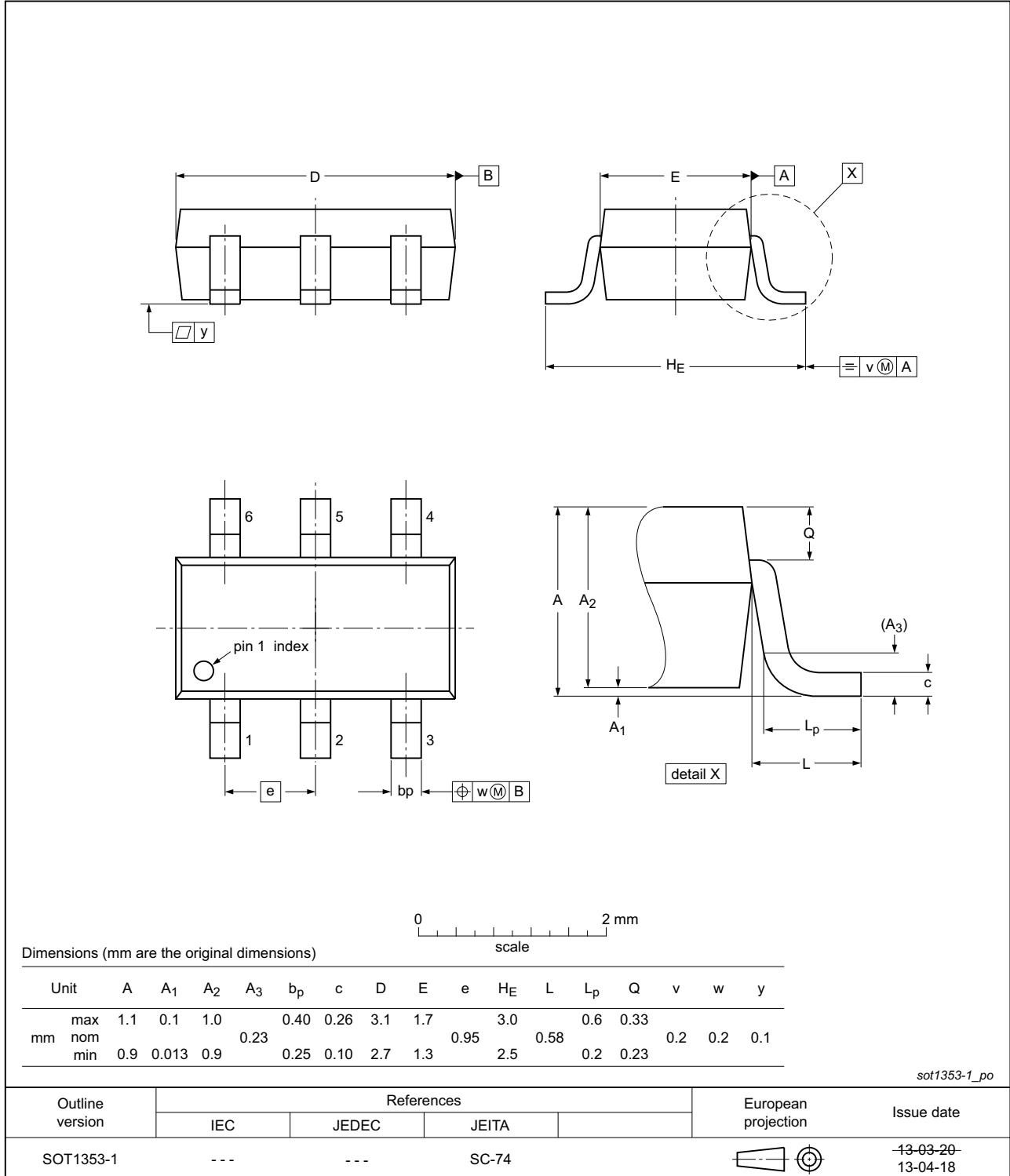


Fig 30. Package outline SOT1353-1 (TSOP6)

14. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note AN10365 “Surface mount reflow soldering description”.

14.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

14.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

14.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

14.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see [Figure 31](#)) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with [Table 22](#) and [23](#)

Table 22. SnPb eutectic process (from J-STD-020D)

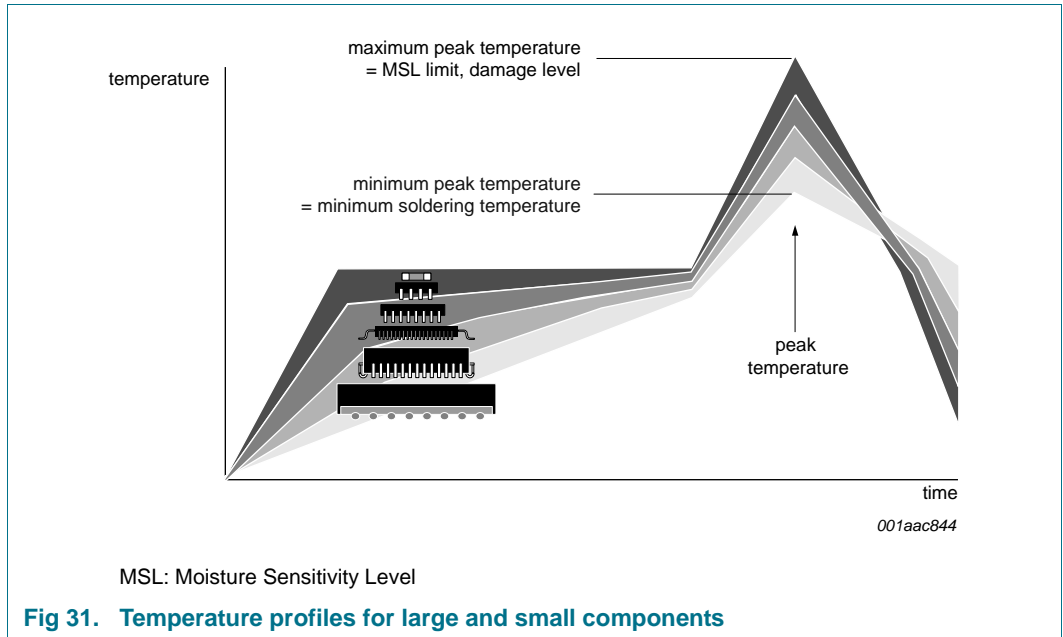
| Package thickness (mm) | Package reflow temperature (°C) | |
|------------------------|---------------------------------|-------|
| | Volume (mm ³) | |
| | < 350 | ≥ 350 |
| < 2.5 | 235 | 220 |
| ≥ 2.5 | 220 | 220 |

Table 23. Lead-free process (from J-STD-020D)

| Package thickness (mm) | Package reflow temperature (°C) | | |
|------------------------|---------------------------------|-------------|--------|
| | Volume (mm ³) | | |
| | < 350 | 350 to 2000 | > 2000 |
| < 1.6 | 260 | 260 | 260 |
| 1.6 to 2.5 | 260 | 250 | 245 |
| > 2.5 | 250 | 245 | 245 |

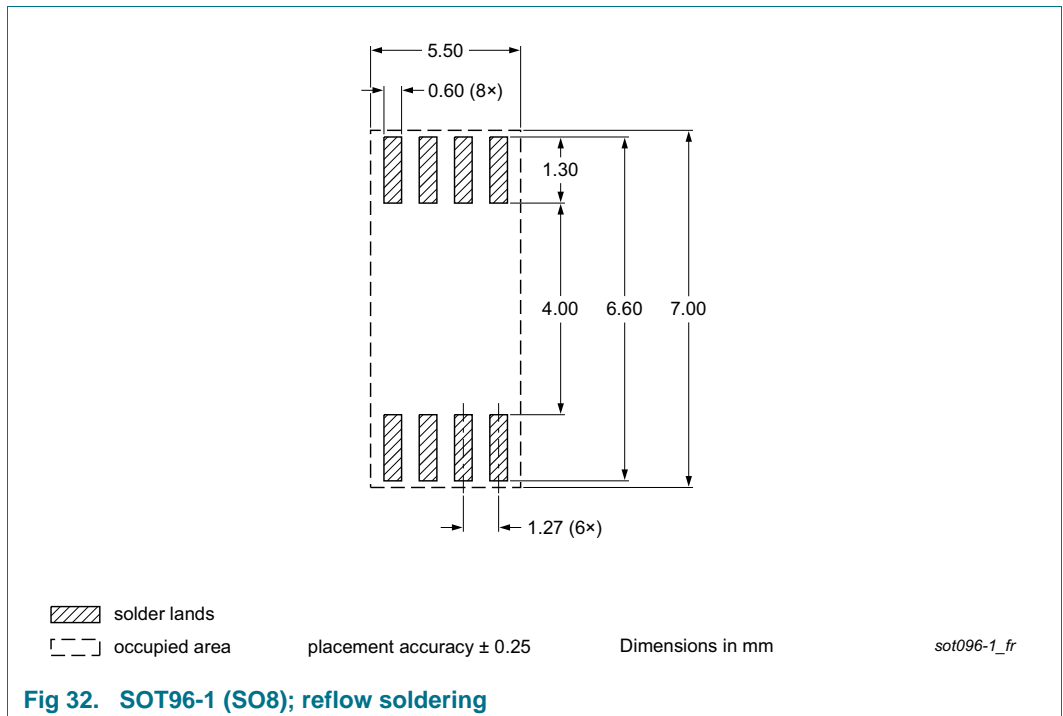
Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

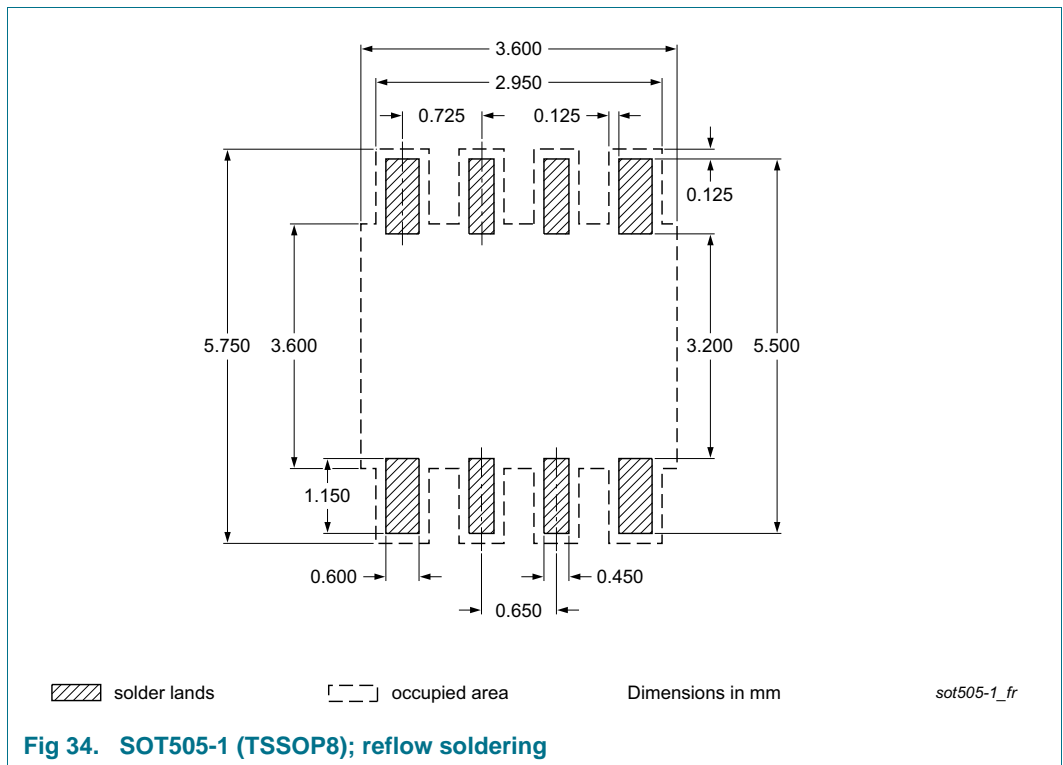
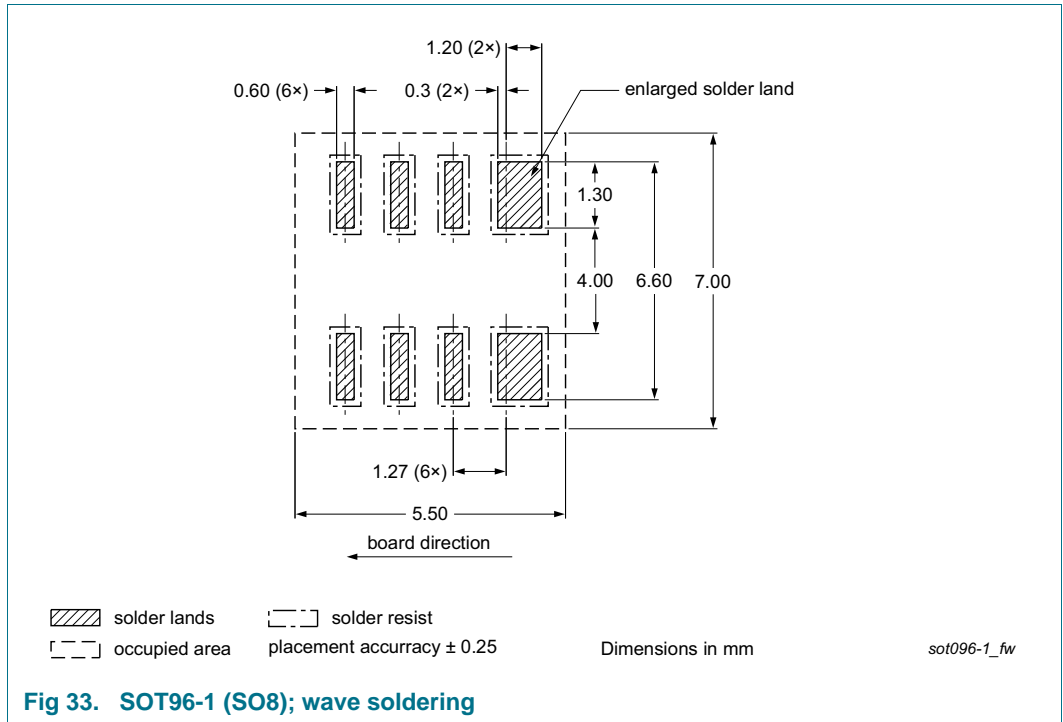
Studies have shown that small packages reach higher temperatures during reflow soldering, see [Figure 31](#).



For further information on temperature profiles, refer to Application Note AN10365 “Surface mount reflow soldering description”.

15. Soldering: PCB footprints





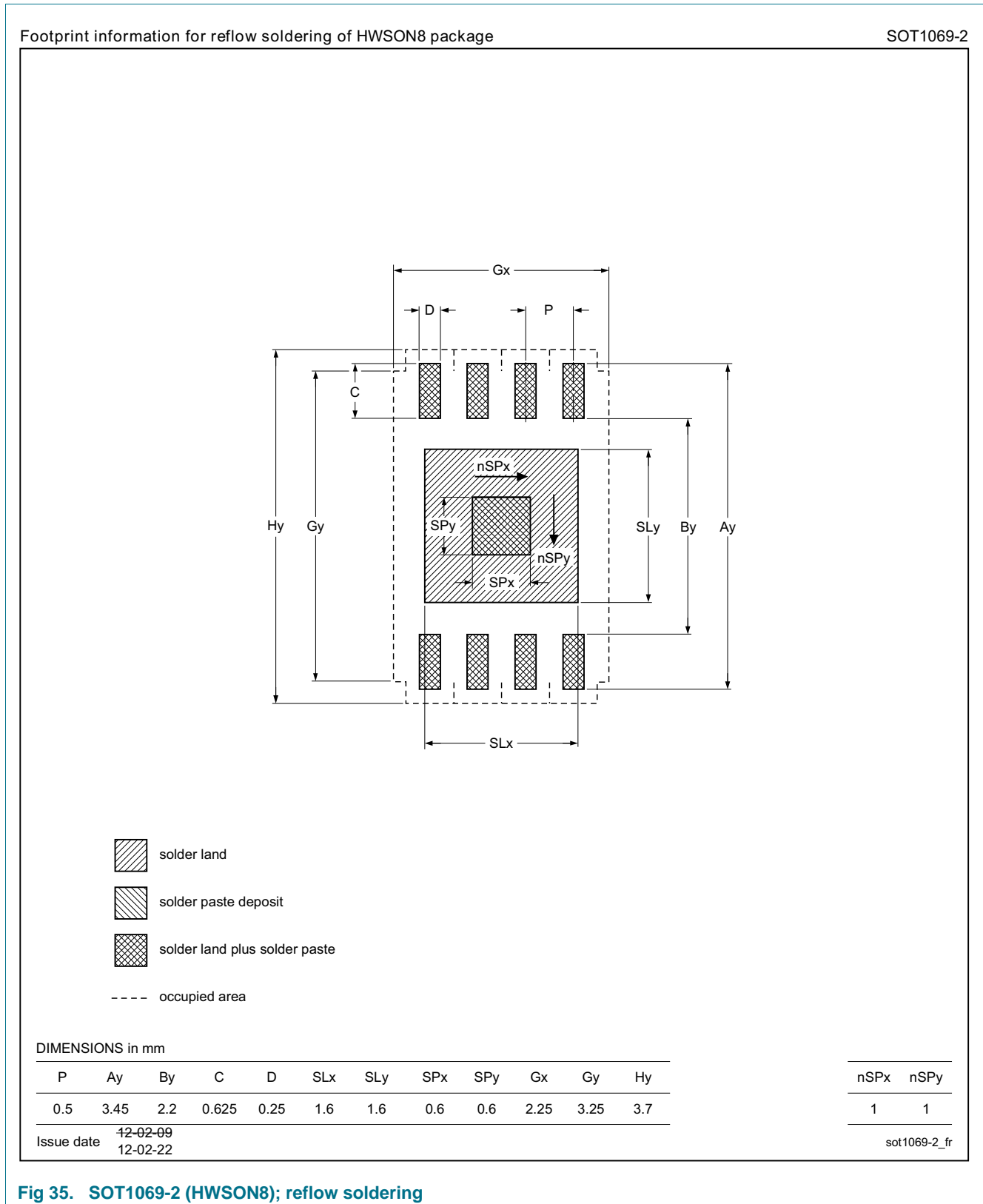


Fig 35. SOT1069-2 (HWSO8); reflow soldering

16. Abbreviations

Table 24. Abbreviations

| Acronym | Description |
|----------------------|------------------------------|
| A-to-D | Analog-to-Digital |
| CDM | Charged Device Model |
| ESD | ElectroStatic Discharge |
| HBM | Human Body Model |
| I ² C-bus | Inter-Integrated Circuit bus |
| I/O | Input/Output |
| LSB | Least Significant Bit |
| LSByte | Least Significant Byte |
| MSB | Most Significant Bit |
| MSByte | Most Significant Byte |
| PCB | Printed-Circuit Board |
| POR | Power-On Reset |
| SMD | Solder Mask Defined |

17. Revision history

Table 25. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|----------------|--|--------------------|---------------|-------------|
| PCT2075 v.7 | 20140306 | Product data sheet | - | PCT2075 v.6 |
| Modifications: | <ul style="list-style-type: none"> Table 10 "Conf register": B[7:5] description changed from "reserved for manufacturer's use; should be kept as zeroes for normal operation" to "unused; any value written to these bits does not affect operation" (this is a clarification only; there is no change to the device) | | | |
| PCT2075 v.6 | 20140124 | Product data sheet | - | PCT2075 v.5 |
| PCT2075 v.5 | 20131209 | Product data sheet | - | PCT2075 v.4 |
| PCT2075 v.4 | 20130719 | Product data sheet | - | PCT2075 v.3 |
| PCT2075 v.3 | 20130521 | Product data sheet | - | PCT2075 v.2 |
| PCT2075 v.2 | 20130506 | Product data sheet | - | PCT2075 v.1 |
| PCT2075 v.1 | 20130405 | Product data sheet | - | - |

18. Legal information

18.1 Data sheet status

| Document status ^{[1][2]} | Product status ^[3] | Definition |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification | This document contains data from the preliminary specification. |
| Product [short] data sheet | Production | This document contains the product specification. |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

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