

## 1. Features and benefits

- Pin-for-pin replacement for industry standard LM75 and LM75A and offers improved temperature resolution of 0.125 °C and specification of a single part over power supply range from 2.8 V to 5.5 V
- I<sup>2</sup>C-bus interface with up to 8 devices on the same bus
- Power supply range from 2.8 V to 5.5 V
- Temperatures range from -55 °C to +125 °C
- Frequency range 20 Hz to 400 kHz with bus fault time-out to prevent hanging up the bus
- 11-bit ADC that offers a temperature resolution of 0.125 °C
- Temperature accuracy of:
  - ◆ ±0.5 °C from 0°C to +50 °C
  - ◆ ±1 °C from -25 °C to +100 °C
  - ◆ ±1.5 °C from -55 °C to +125 °C
- Programmable temperature threshold and hysteresis set points
- Supply current of 1.0 μA in shutdown mode for power conservation
- Stand-alone operation as thermostat at power-up
- ESD protection exceeds 4000 V HBM per JESD22-A114 and 2000 V CDM per JESD22-C101
- Latch-up testing is done to JEDEC Standard JESD78 which exceeds 100 mA

## 2. Applications

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

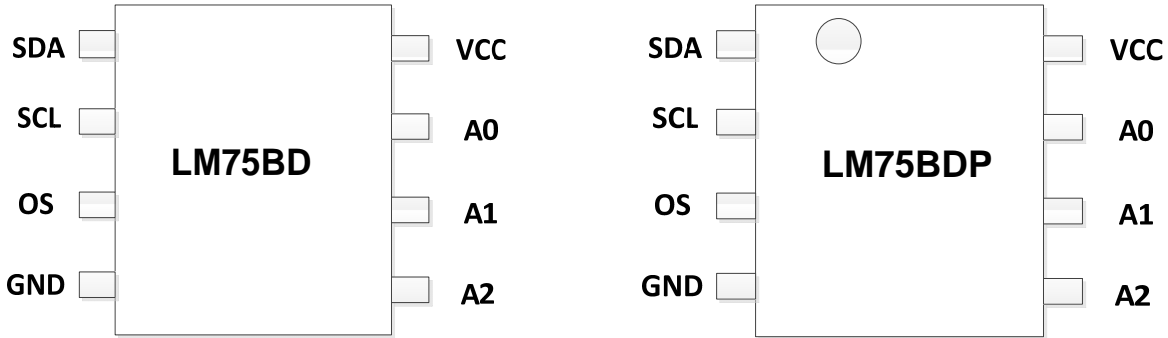
## 3. Ordering information

**Table 1. Ordering information**

| Type number | Topside mark | Package |   | Version |
|-------------|--------------|---------|---|---------|
|             |              | Name    | Description   |         |
| LM75BD      | LM75BD       | SOP8    | plastic small outline package; 8 leads;             | V1.0    |
| LM75BDP     | LM75BDP      | TSSOP8  | plastic thin shrink small outline package; 8 leads; | V1.0    |

## 4. Pinning information

### 4.1 Pinning



### 4.2 Pin description

Table 3. Pin description

| Symbol          | Pin | Description   |
|-----------------|-----|---|
| SDA             | 1   | Digital I/O. I <sup>2</sup> C-bus serial bidirectional data line; open-drain. |
| SCL             | 2   | Digital input. I <sup>2</sup> C-bus serial clock input.                       |
| OS              | 3   | Overtemperature Shutdown output; open-drain.                                  |
| GND             | 4   | 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 <sub>CC</sub> | 8   | Power supply.   |

## 5. General description

The LM75B is a temperature-to-digital converter using an on-chip band gap temperature sensor and Sigma-Delta A-to-D conversion technique with an over temperature detection output. The LM75B 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 as described in [Section 7 “Functional description”](#); temperature register (Temp) to store the digital temp reading, and set-point registers (Tos and Thyst) to store programmable over temperature shutdown and hysteresis limits, that can be communicated by a controller via the 2-wire serial I<sup>2</sup>C-bus interface. The device also includes an open-drain output (OS) which becomes active when the temperature exceeds the programmed limits. There are three selectable logic address pins so that eight devices can be connected on the same bus without address conflict.

The LM75B can be configured for different operation conditions. It can be set in normal mode to periodically monitor the ambient temperature, or in shutdown mode to minimize power consumption. 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 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 LM75B is accessed the conversion in process is not interrupted (that is, the I<sup>2</sup>C-bus section is totally independent of the Sigma-Delta converter section) and accessing the LM75B 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.

The LM75B 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.

## 6. Block diagram

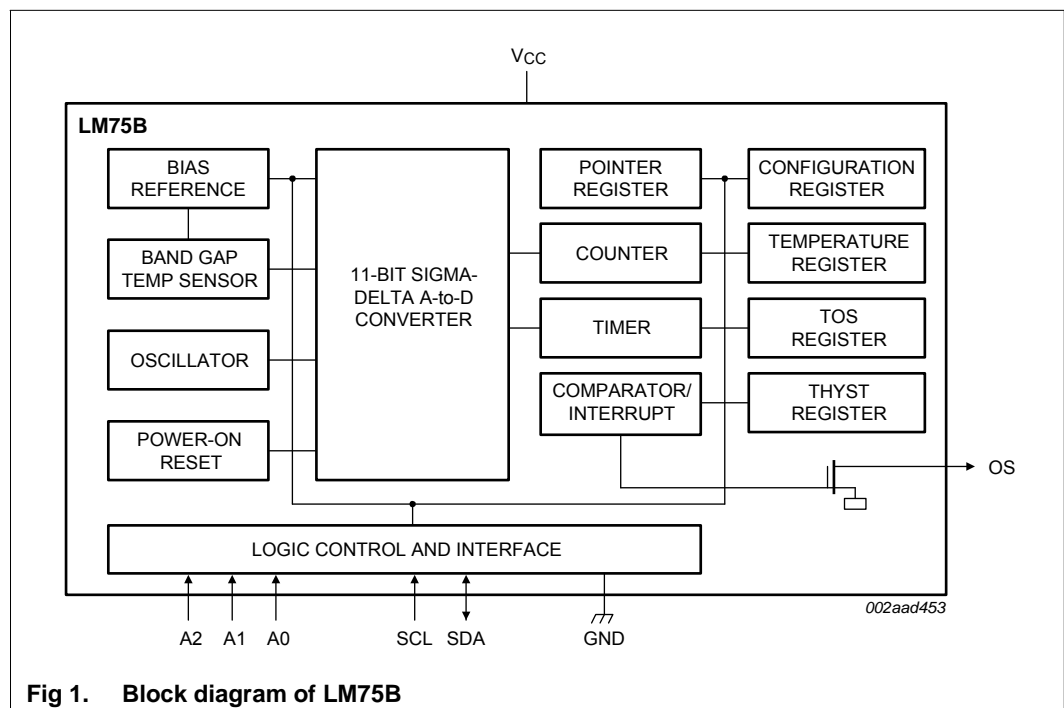


Fig 1. Block diagram of LM75B

## 7. Functional description

### 7.1 General operation

The LM75B 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 I<sup>2</sup>C-bus. Reading temperature data does not affect the conversion in progress during the read operation.

The device 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 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 10 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 I<sup>2</sup>C-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 over temperature shutdown threshold data (or  $T_{th(ots)}$ ) 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.

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.

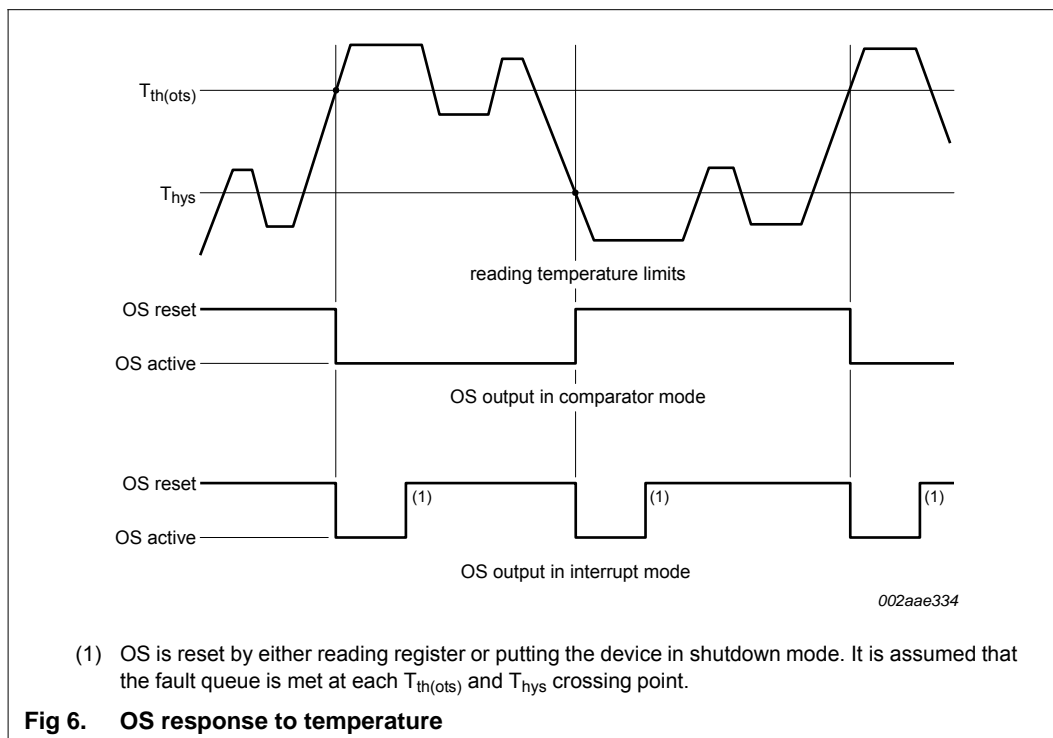
In OS comparator mode, the OS output behaves like a thermostat. It becomes active when the Temp exceeds the  $T_{th(ots)}$ , and is reset when the Temp drops below the  $T_{hys}$ . Reading the device registers or putting the device into shutdown does not change the state of the OS output. The OS output 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  $T_{th(ots)}$ ; then it remains active indefinitely until being reset by a read of any register. Once the OS output has been activated by crossing  $T_{th(ots)}$  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:  $T_{th(ots)}$  trip, Reset,  $T_{hys}$  trip, Reset,  $T_{th(ots)}$  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 device is put into normal operation mode, the  $T_{th(ots)}$  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 not available until the first conversion is completed in about 100 ms.

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



## 7.2 I<sup>2</sup>C-bus serial interface

The LM75B can be connected to a compatible 2-wire serial interface I<sup>2</sup>C-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 I<sup>2</sup>C-bus common pull-up resistors have not been installed as required for I<sup>2</sup>C-bus, then an external pull-up resistor, about 10 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  $t_{to}$  (75 ms minimum / 13.3 Hz; guaranteed at 50 ms minimum / 20 Hz), the LM75B will reset to the idle state (SDA released) and wait for a new START condition. This ensures that the LM75B will never hang up the bus should there be conflict in the transmission sequence.

## 7.3 Slave address

The LM75B slave address on the I<sup>2</sup>C-bus is partially defined by the logic applied to the device address pins A2, A1 and A0. Each of them is typically connected either to GND for logic 0, or to V<sub>CC</sub> for logic 1. These pins represent the three LSB bits of the device 7-bit address. The other four MSB bits of the address data are preset to '1001' by hard wiring inside the LM75B. [Table 4](#) shows the device's complete address and indicates that up to 8 devices can be connected to the same bus without address conflict. Because the input pins, SCL, SDA and A2 to A0, are not internally biased, it is important that they should not be left floating in any application.

**Table 4. Address table**  
1 = HIGH; 0 = LOW.

| MSB |   |   |   | LSB |    |    |
|-----|---|---|---|-----|----|----|
| 1   | 0 | 0 | 1 | A2  | A1 | A0 |

## 7.4 Register list

The LM75B contains four data registers beside the pointer register as listed in [Table 5](#). The pointer value, read/write capability and default content at power-up of the registers are also shown in [Table 5](#).

**Table 5. 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 | n/a       | Temperature register: contains two 8-bit data bytes; to store the measured Temp data.   |
| Tos           | 03h           | R/W       | 5000h     | Over temperature shutdown threshold register: contains two 8-bit data bytes; to store the over temperature shutdown $T_{th(ots)}$ 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.   |

## 7.4.1 Pointer register

The Pointer register contains an 8-bit data byte, of which the two LSB bits represent the pointer value of the other four registers, and the other 6 MSB bits are equal to 0, as shown in [Table 6](#) and [Table 7](#). 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 6. Pointer register**

| B7 | B6 | B5 | B4 | B3 | B2 | B[1:0]        |
|----|----|----|----|----|----|---------------|
| 0  | 0  | 0  | 0  | 0  | 0  | pointer value |

**Table 7. Pointer value**

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

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 LM75B 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 LM75B 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 00 and the Temp register is selected; users can then read the Temp data without specifying the pointer byte.

## 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 8](#) shows the bit assignments of this register.

**Table 8. Conf register**

*Legend: \* = default value.*

| Bit    | Symbol        | Access | Value | Description  |
|--------|---------------|--------|-------|--|
| B[7:5] | reserved      | R/W    | 000*  | reserved for manufacturer's use; should be kept as zeroes for normal 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   |

**Table 8. Conf register ...continued**  
 Legend: \* = default value.

| Bit | Symbol      | Access | Value | Description                     |
|-----|-------------|--------|-------|---------------------------------|
| 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 9](#) shows the bit arrangement of the Temp data in the data bytes.

**Table 9. 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 must be all collected by the controller to complete the bus operation. However, only the 11 most significant bits should be used, and the 5 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 10](#).

**Table 10. 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   |



**Table 10. Temp register value ...continued**

| 11-bit binary<br>(two's complement) | Hexadecimal value | Decimal value | Value      |
|-------------------------------------|-------------------|---------------|------------|
| 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 LM75B is defined exactly in the same way as for the standard LM75 and it is here similar to the Tos and Thyst registers.

The only MSByte of the temperature can also be read with the use of a one-byte reading command. 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 ( $T_{th(ots)}$ ) 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 the same as register Temp. 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 11](#) and [Table 12](#) 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 11. 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 12. 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 to complete the bus operation. 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.

[Table 13](#) shows examples of the limit data and value.

**Table 13. Tos and Thyst limit data and value**

| 11-bit binary<br>(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  |

## 7.5 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 200 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  $T_{th(ots)}$  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  $T_{th(ots)}$  or dropping below  $T_{hys}$ , the OS output will remain active indefinitely until reading a register, then the OS output is reset.

Temperature limits  $T_{th(ots)}$  and  $T_{hys}$  must be selected so that  $T_{th(ots)} > T_{hys}$ . 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 14](#) shows the one-to-one relationship between them. At power-up, fault queue data = 0 and fault queue value = 1.

**Table 14. 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 device draws a small current of approximately 1.0  $\mu\text{A}$  and the power dissipation is minimized; the temperature conversion stops, but the I<sup>2</sup>C-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 LM75B always powers-up in its default state with:

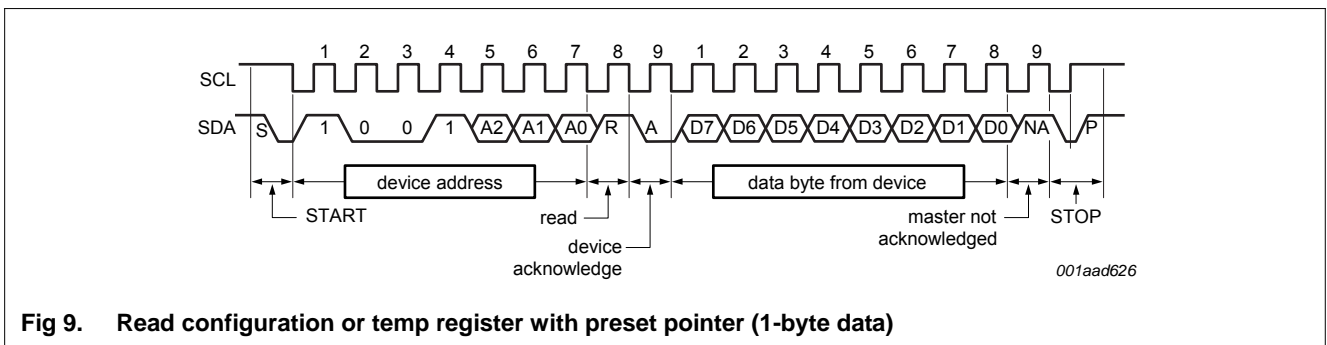
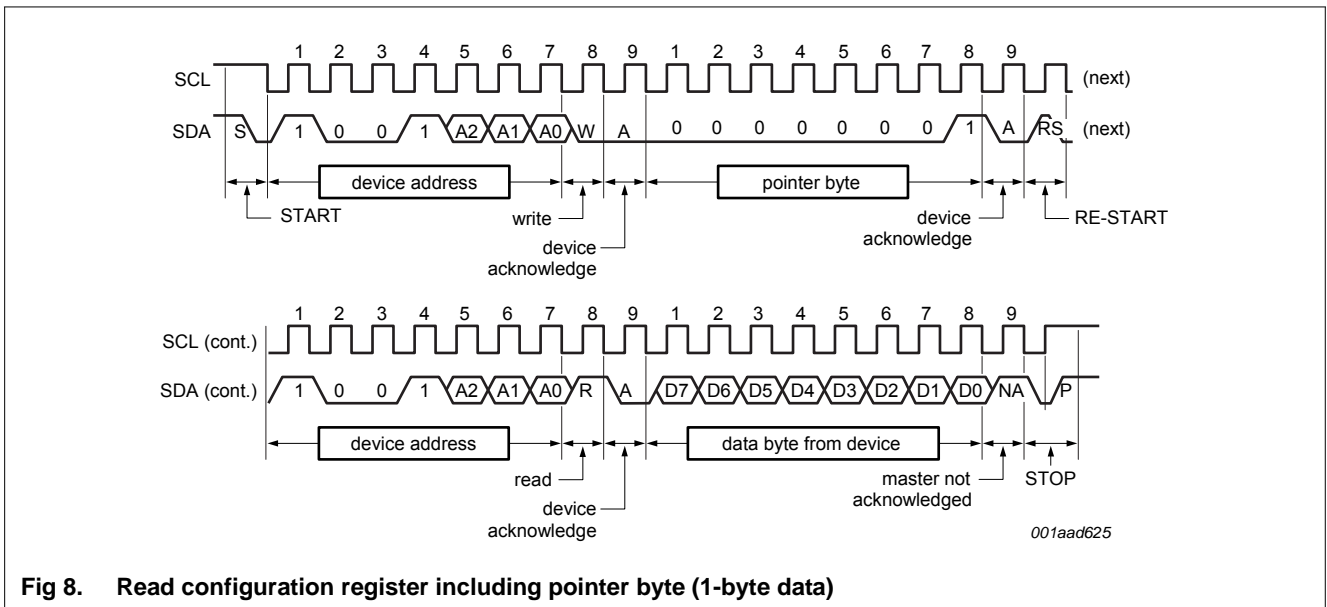
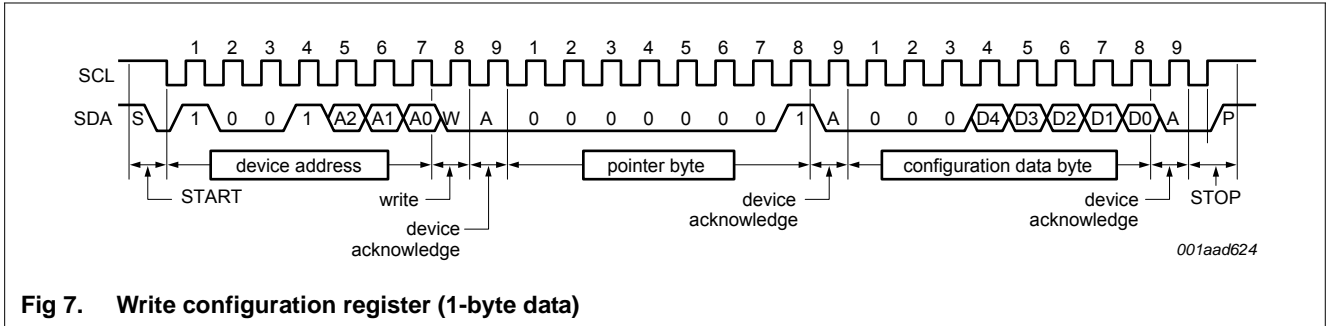
- Normal operation mode
- OS comparator mode
- $T_{th(ots)} = 80\text{ }^{\circ}\text{C}$
- $T_{hys} = 75\text{ }^{\circ}\text{C}$
- OS output active state is LOW
- Pointer value is logic 00 (Temp)

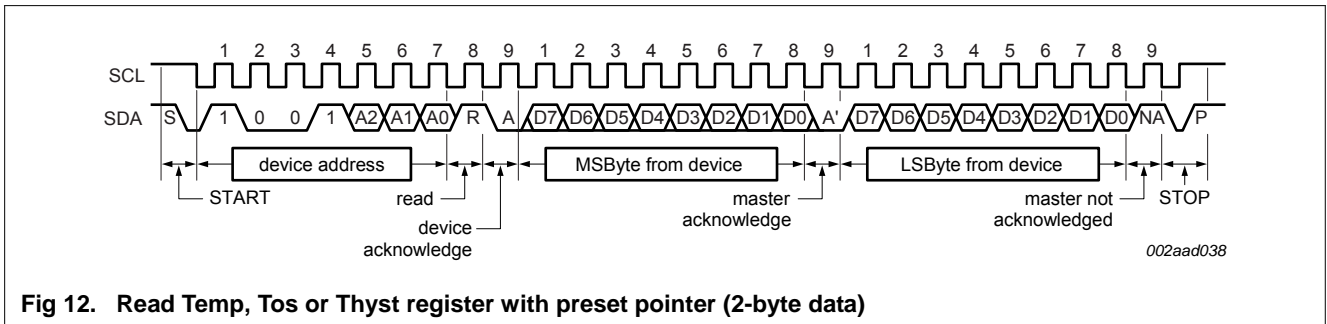
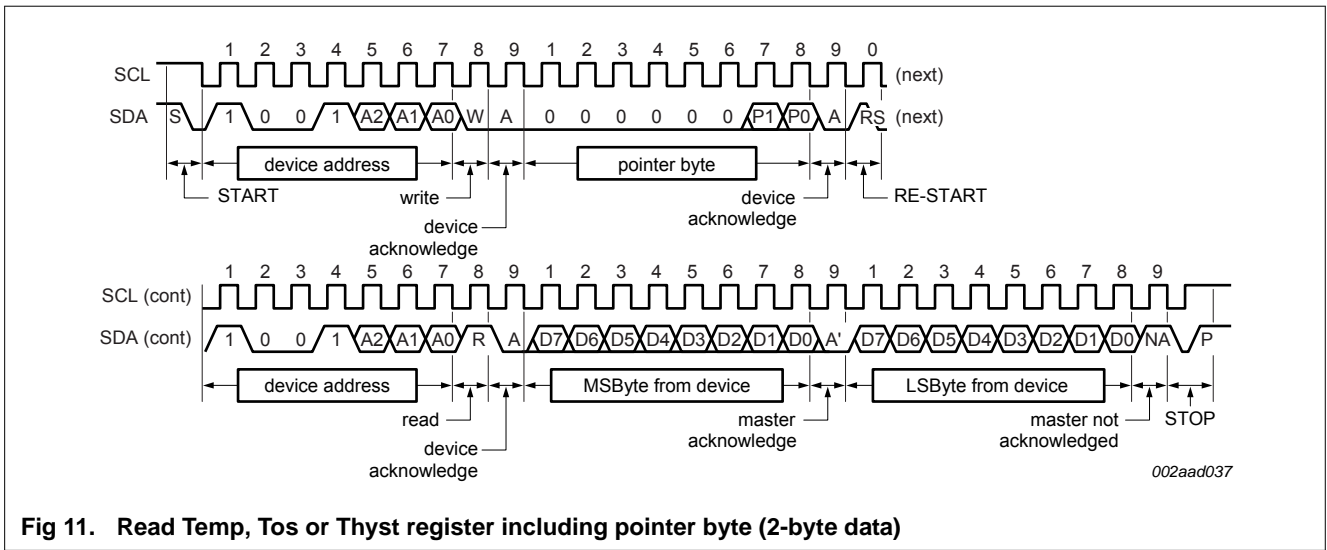
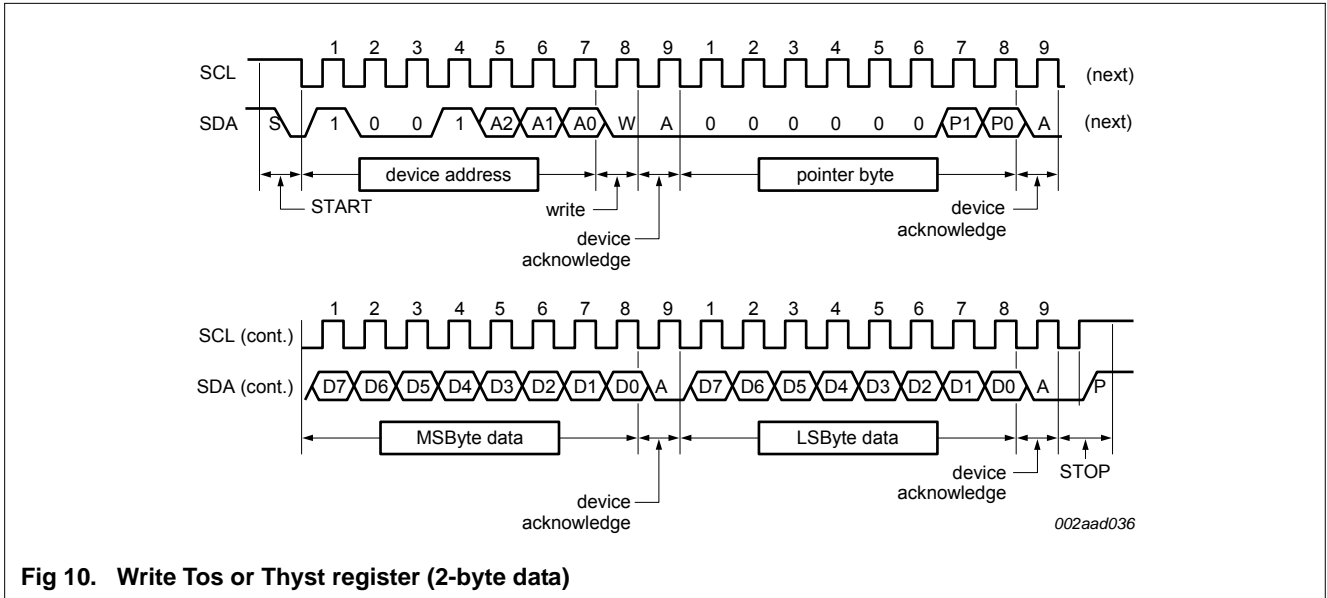
When the power supply voltage is dropped below the device power-on reset level of approximately 1.0 V (POR) for over 2  $\mu\text{s}$  and then rises up again, the device will be reset to its default condition as listed above.

## 7.10 Protocols for writing and reading the registers

The communication between the host and the LM75B must strictly follow the rules as defined by the I<sup>2</sup>C-bus management. The protocols for LM75B register read/write operations are illustrated in [Figure 7](#) to [Figure 12](#) together with the following definitions:

1. Before a communication, the I<sup>2</sup>C-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 LM75B. 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.





## 8. Application design-in information

### 8.1 Typical application

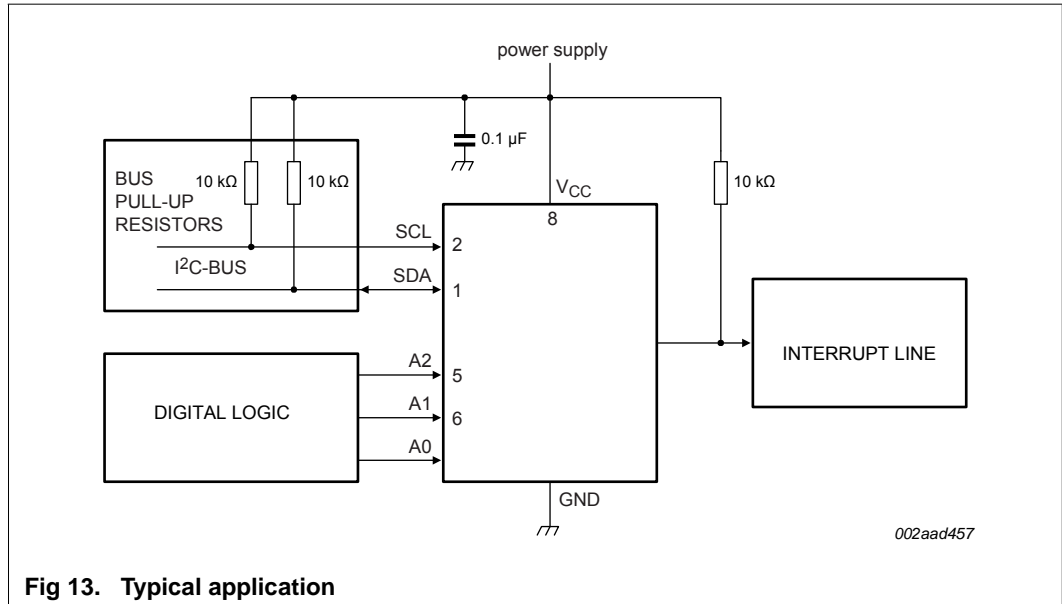


Fig 13. Typical application

### 8.2 LM75A and LM75B comparison

Table 15. LM75A and LM75B comparison

| Description  | LM75A           | LM75B          |
|--|-----------------|----------------|
| availability of the XSON8U (3 mm × 2 mm) package type                | no              | yes            |
| OS output auto-reset when SHUTDOWN bit is set in interrupt mode      | no              | yes            |
| support single-byte reading of the Temp registers without bus lockup | no              | yes            |
| bus fault time-out (75 ms, 200 ms)                                   | no              | yes            |
| minimum data hold time ( $t_{HD,DAT}$ )                              | 10 ns           | 0 ns           |
| ratio of conversion time / conversion period (typical)               | 100 ms / 100 ms | 10 ms / 100 ms |
| supply current in shutdown mode (typical value)                      | 3.5 μA          | 0.2 μA         |
| HBM ESD protection level (minimum)                                   | >2000 V         | >4000 V        |
| MM ESD protection level (minimum)                                    | >200 V          | >450 V         |
| CDM ESD protection level (minimum)                                   | >1000 V         | >2000 V        |

### 8.3 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 LM75B 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.

If you would like to calculate the effect of self-heating, use [Equation 1](#) below:

[Equation 1](#) is the formula to calculate the effect of self-heating:

$$\Delta T = R_{th(j-a)} \times [(V_{DD} \times I_{DD(AV)}) + (V_{OL(SDA)} \times I_{OL(sink)(SDA)}) + (V_{OL(EVENT)} \times I_{OL(sink)EVENT})] \quad (1)$$

where:

$$\Delta T = T_j - T_{amb}$$

$T_j$  = junction temperature

$T_{amb}$  = ambient temperature

$R_{th(j-a)}$  = package thermal resistance

$V_{DD}$  = supply voltage

$I_{DD(AV)}$  = average supply current

$V_{OL(SDA)}$  = LOW-level output voltage on pin SDA

$V_{OL(EVENT)}$  = LOW-level output voltage on pin  $\overline{EVENT}$

$I_{OL(sink)(SDA)}$  = SDA output current LOW

$I_{OL(sink)EVENT}$  =  $\overline{EVENT}$  output current LOW

#### Calculation example:

$T_{amb}$  (typical temperature inside the notebook) = 50 °C

$I_{DD(AV)}$  = 400  $\mu$ A

$V_{DD}$  = 3.6 V

Maximum  $V_{OL(SDA)}$  = 0.4 V

$I_{OL(sink)(SDA)}$  = 1 mA



$$V_{OL(EVENT)} = 0.4 \text{ V}$$

$$I_{OL(sink)EVENT} = 3 \text{ mA}$$

$$R_{th(j-a)} = 56 \text{ }^{\circ}\text{C/W}$$

Self heating due to power dissipation is:

$$\Delta T = 56 \times [(3.6 \times 0.4) + (0.4 \times 3) + (0.4 \times 1)] = 56 \text{ }^{\circ}\text{C/W} \times 3.04 \text{ mW} = 0.17 \text{ }^{\circ}\text{C} \quad (2)$$

## 8.4 Noise effect

The LM75B device design includes the implementation of basic features for a good noise immunity:

- The 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 LM75B will not hold the I<sup>2</sup>C lines LOW when  $V_{CC}$  is not supplied and therefore allow continued I<sup>2</sup>C-bus operation if the LM75B 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 16. 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     | -    | 10.0 | 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 17. Recommended operating characteristics**

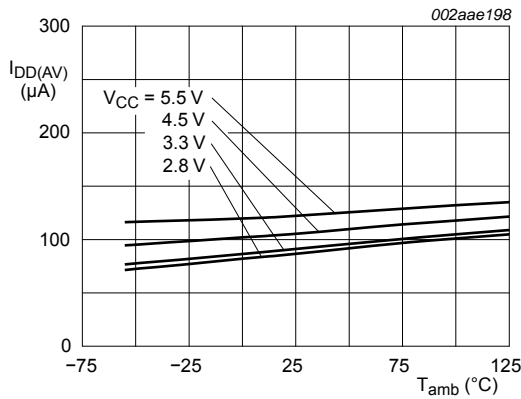
| Symbol    | Parameter           | Conditions | Min | Typ | Max  | Unit |
|-----------|---------------------|------------|-----|-----|------|------|
| $V_{CC}$  | supply voltage      |            | 2.8 | -   | 5.5  | V    |
| $T_{amb}$ | ambient temperature |            | -55 | -   | +125 | °C   |

## 11. Static characteristics

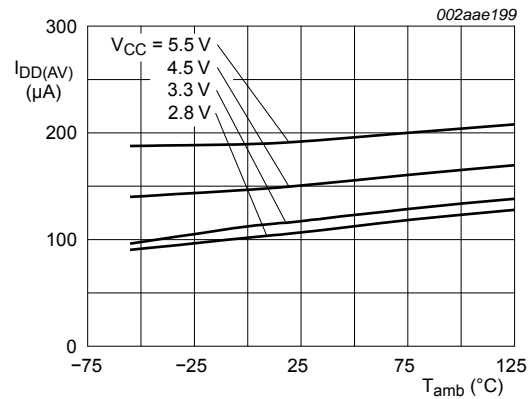
**Table 18. Static characteristics**
 $V_{CC} = 2.8\text{ V to }5.5\text{ V}; T_{amb} = -55\text{ }^{\circ}\text{C to }+125\text{ }^{\circ}\text{C};$  unless otherwise specified.

| Symbol        | Parameter                                      | Conditions  | Min                 | Typ <sup>[1]</sup> | Max                 | Unit               |
|---------------|--|---|---------------------|--------------------|---------------------|--------------------|
| $T_{acc}$     | temperature accuracy                           | $T_{amb} = -25\text{ }^{\circ}\text{C to }+100\text{ }^{\circ}\text{C}$ | -2                  | -                  | +2                  | $^{\circ}\text{C}$ |
|               |  | $T_{amb} = -55\text{ }^{\circ}\text{C to }+125\text{ }^{\circ}\text{C}$ | -3                  | -                  | +3                  | $^{\circ}\text{C}$ |
| $T_{res}$     | temperature resolution                         | 11-bit digital temp data  | -                   | 0.125              | -                   | $^{\circ}\text{C}$ |
| $t_{conv(T)}$ | temperature conversion time                    | normal mode   | -                   | 10                 | -                   | ms                 |
| $T_{conv}$    | conversion period                              | normal mode   | -                   | 100                | -                   | ms                 |
| $I_{DD(AV)}$  | average supply current                         | normal mode: I <sup>2</sup> C-bus inactive                              | -                   | 100                | 200                 | $\mu\text{A}$      |
|               |  | normal mode: I <sup>2</sup> C-bus active;<br>$f_{SCL} = 400\text{ kHz}$ | -                   | -                  | 300                 | $\mu\text{A}$      |
|               |  | shutdown mode   | -                   | 0.2                | 1.0                 | $\mu\text{A}$      |
| $V_{IH}$      | HIGH-level input voltage                       | digital pins (SCL, SDA, A2 to A0)                                       | $0.7 \times V_{CC}$ | -                  | $V_{CC} + 0.3$      | V                  |
| $V_{IL}$      | LOW-level input voltage                        | digital pins  | -0.3                | -                  | $0.3 \times V_{CC}$ | 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; $V_I = V_{CC}$  | -1.0                | -                  | +1.0                | $\mu\text{A}$      |
| $I_{IL}$      | LOW-level input current                        | digital pins; $V_I = 0\text{ V}$  | -1.0                | -                  | +1.0                | $\mu\text{A}$      |
| $V_{OL}$      | LOW-level output voltage                       | SDA and OS pins; $I_{OL} = 3\text{ mA}$                                 | -                   | -                  | 0.4                 | V                  |
|               |  | $I_{OL} = 4\text{ mA}$  | -                   | -                  | 0.8                 | V                  |
| $I_{LO}$      | output leakage current                         | SDA and OS pins; $V_{OH} = V_{CC}$                                      | -                   | -                  | 10                  | $\mu\text{A}$      |
| $N_{fault}$   | number of faults                               | programmable; conversions in overtemperature-shutdown fault queue       | 1                   | -                  | 6                   |                    |
| $T_{th(ots)}$ | overtemperature shutdown threshold temperature | default value   | -                   | 80                 | -                   | $^{\circ}\text{C}$ |
| $T_{hys}$     | hysteresis temperature                         | default value   | -                   | 75                 | -                   | $^{\circ}\text{C}$ |
| $C_i$         | input capacitance                              | digital pins  | -                   | 20                 | -                   | pF                 |

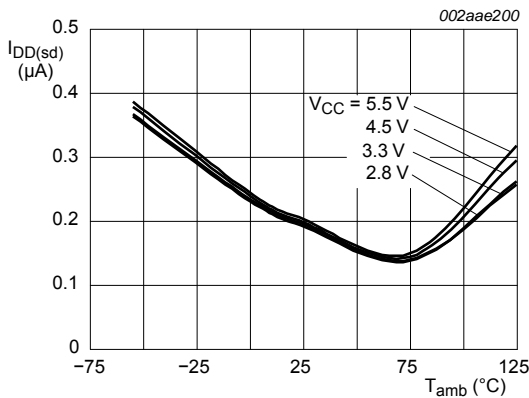
[1] Typical values are at  $V_{CC} = 3.3\text{ V}$  and  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .



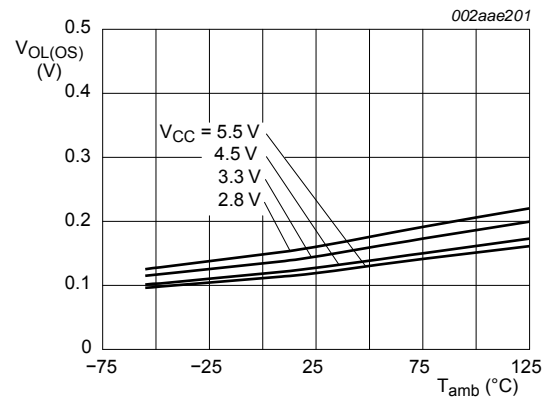
**Fig 14. Average supply current versus temperature; I<sup>2</sup>C-bus inactive**



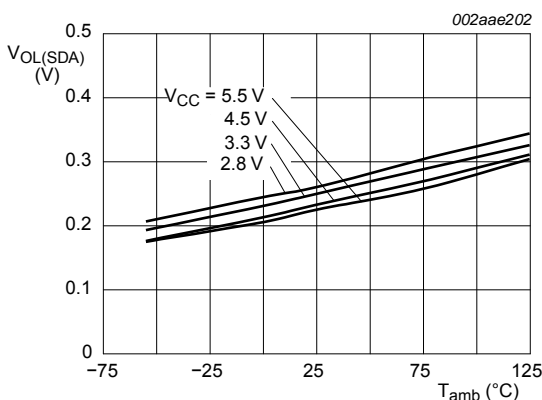
**Fig 15. Average supply current versus temperature; I<sup>2</sup>C-bus active**



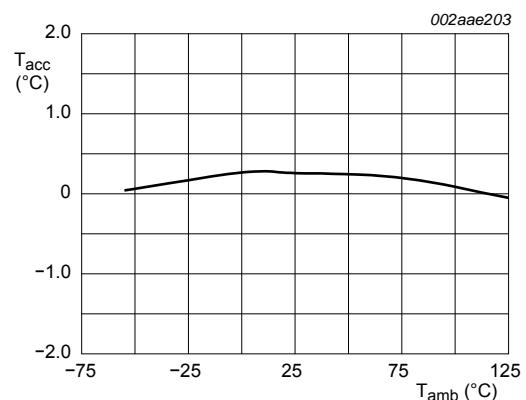
**Fig 16. Shutdown mode supply current versus temperature**



**Fig 17. LOW-level output voltage on pin OS versus temperature; I<sub>OL</sub> = 4 mA**



**Fig 18. LOW-level output voltage on pin SDA versus temperature; I<sub>OL</sub> = 4 mA**



**Fig 19. Typical temperature accuracy versus temperature; V<sub>CC</sub> = 3.3 V**

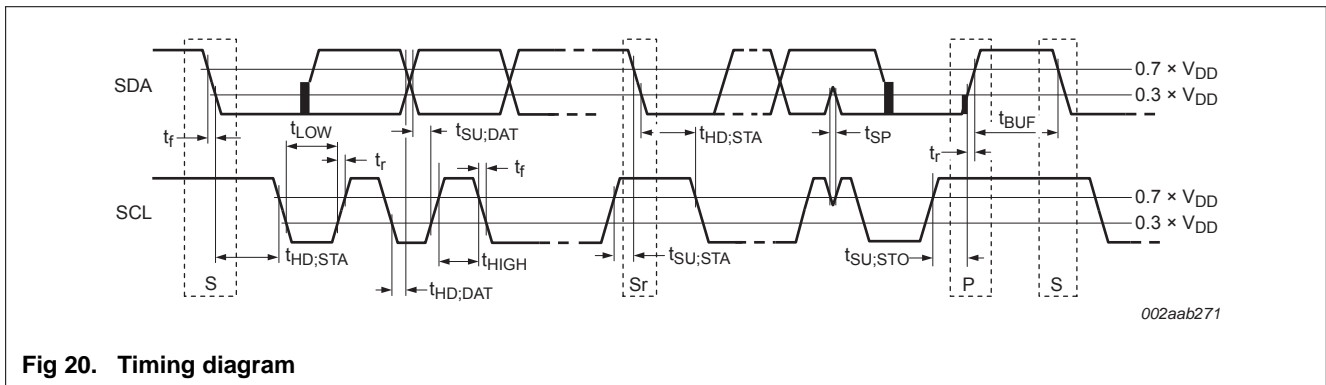
## 12. Dynamic characteristics

**Table 19. I<sup>2</sup>C-bus interface dynamic characteristics<sup>[1]</sup>**

$V_{CC} = 2.8\text{ V to }5.5\text{ V}$ ;  $T_{amb} = -55\text{ }^{\circ}\text{C to }+125\text{ }^{\circ}\text{C}$ ; unless otherwise specified.

| Symbol       | Parameter                            | Conditions  | Min                       | Typ | Max | Unit          |
|--------------|--------------------------------------|---|---------------------------|-----|-----|---------------|
| $f_{SCL}$    | SCL clock frequency                  | see <a href="#">Figure 20</a>   | 0.02                      | -   | 400 | kHz           |
| $t_{HIGH}$   | HIGH period of the SCL clock         |   | 0.6                       | -   | -   | $\mu\text{s}$ |
| $t_{LOW}$    | LOW period of the SCL clock          |   | 1.3                       | -   | -   | $\mu\text{s}$ |
| $t_{HD;STA}$ | hold time (repeated) START condition |   | 100                       | -   | -   | ns            |
| $t_{SU;DAT}$ | data set-up time                     |   | 100                       | -   | -   | ns            |
| $t_{HD;DAT}$ | data hold time                       |   | 0                         | -   | -   | ns            |
| $t_{SU;STO}$ | set-up time for STOP condition       |   | 100                       | -   | -   | ns            |
| $t_f$        | fall time                            | SDA and OS outputs;<br>$C_L = 400\text{ pF}$ ; $I_{OL} = 3\text{ mA}$ | -                         | 250 | -   | ns            |
| $t_{to}$     | time-out time                        |   | <a href="#">[2][3]</a> 75 | -   | 200 | ms            |

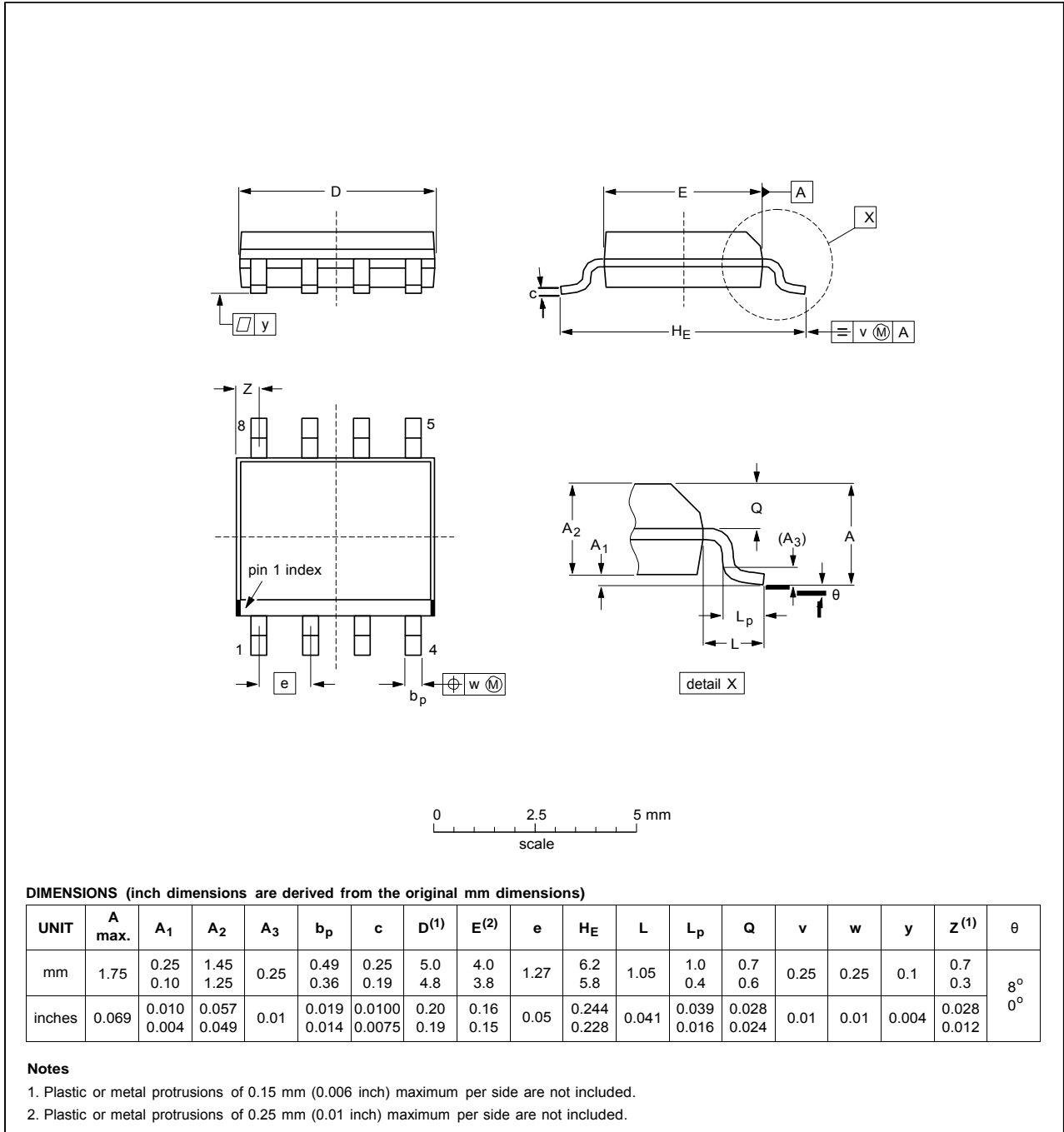
- [1] These specifications are guaranteed by design and not tested in production.
- [2] This is the SDA time LOW for reset of serial interface.
- [3] Holding the SDA line LOW for a time greater than  $t_{to}$  will cause the LM75B to reset SDA to the idle state of the serial bus communication (SDA set HIGH).



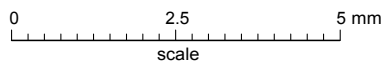
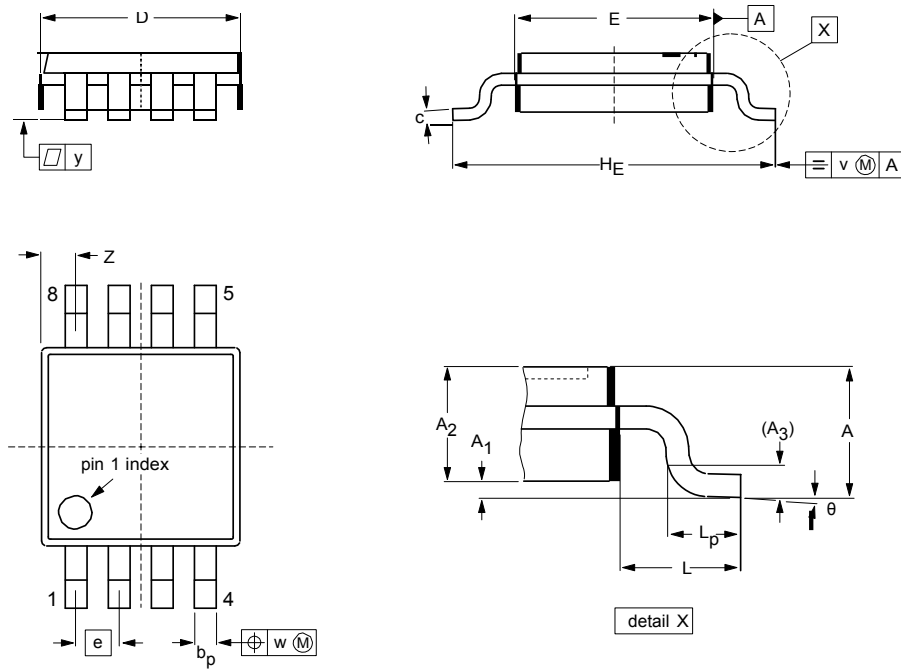
**Fig 20. Timing diagram**

### 13. Package outline

SOP8: plastic small outline package; 8 leads; body width 3.9 mm



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



**DIMENSIONS (mm are the original dimensions)**

| UNIT | A max. | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c            | D <sup>(1)</sup> | E <sup>(2)</sup> | e    | H <sub>E</sub> | L    | L <sub>p</sub> | v   | w   | y   | z <sup>(1)</sup> | θ        |
|------|--------|----------------|----------------|----------------|----------------|--------------|------------------|------------------|------|----------------|------|----------------|-----|-----|-----|------------------|----------|
| mm   | 1.1    | 0.15<br>0.05   | 0.95<br>0.80   | 0.25           | 0.45<br>0.25   | 0.28<br>0.15 | 3.1<br>2.9       | 3.1<br>2.9       | 0.65 | 5.1<br>4.7     | 0.94 | 0.7<br>0.4     | 0.1 | 0.1 | 0.1 | 0.70<br>0.35     | 6°<br>0° |

**Notes**

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.