

## 1.8V Digital Temperature Sensor with I<sup>2</sup>C Interface and Alarm Function

### Features

- Low-voltage alternative to the TMP75AIDR and TMP75AIDGKR
- Operating temperature range : - 55°C ~ +125°C
- Temperature accuracy :  $\pm 0.5^{\circ}\text{C}$  ( $0^{\circ}\text{C} \sim +70^{\circ}\text{C}$ )
- Supply voltage range : 1.4V ~ 5.5V
- Low quiescent current :
  - Normal mode : 15 $\mu\text{A}$  (typ)
  - Shutdown mode : 1 $\mu\text{A}$  (typ)
- Resolution : 12-bits ( $0.0625^{\circ}\text{C}$ )
- Digital Output : I<sup>2</sup>C

### Applications

- Portable, battery-powered applications
- Power-supply temperature monitoring
- Computer peripheral thermal protection
- Laptop computers
- Battery management
- Office machines
- Thermostat controls
- Electro mechanical device temperature
- General temperature measurement
  - Industrial control
  - test equipment
  - Medical instruments

### Description

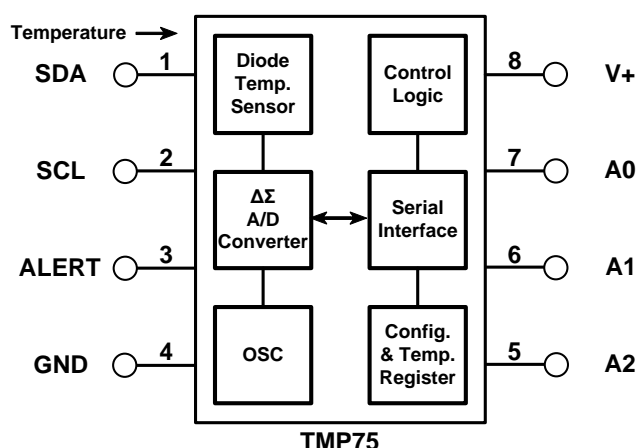
The TMP75 is a fully integrated digital temperature sensor that can work at low voltage (1.8V) and is fully pin and register compatible with NCT75 and ADT75.

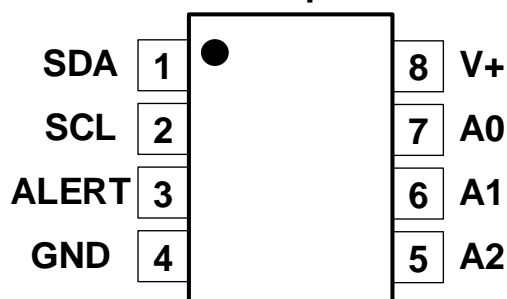
The TMP75 has a  $\pm 1^{\circ}\text{C}$  accuracy over the operating temperature range. The on-chip 12-bit analog-to-digital converter (ADC) provides a temperature resolution of  $0.0625^{\circ}\text{C}$ .

The TMP75 supports up to 8 devices address and provides an over-temperature alarm function. Based on programmable upper and lower temperature limits and an ALERT pin, the TMP75 can be used as a thermostat or an over-temperature alarm.

The TMP75 has been precisely calibrated at the factory, and the user does not need to perform any additional processing on the temperature output.

Block Diagram



**1.8V Digital Temperature Sensor with I<sup>2</sup>C Interface and Alarm Function**
**Pin Configuration and Functions**
**MSOP & SOP Package  
8-Pin Top View**

**Pin Functions**

PIN		DESCRIPTION
NO.	NAME	
1	SDA	Serial data. Open-drain output; requires a pull-up resistor.
2	SCL	Serial clock. Open-drain output; requires a pull-up resistor.
3	ALERT	Over-temperature alert. Open-drain output; requires a pull-up resistor.
4	GND	Ground.
5	A2	Address select. Connect to GND or V+.
6	A1	Address select. Connect to GND or V+.
7	A0	Address select. Connect to GND or V+.
8	V+	Supply voltage, 1.4V~5.5V.

**Specifications**
**Absolute Maximum Ratings**

	MIN	MAX	UNIT
Supply Voltage, V+		6	V
Voltage at SCL, SDA, A2, A1 and A0	-0.5	6	V
Voltage at ALERT	-0.5	((V <sub>+</sub> )+0.3) and ≤5.5	V
Operating Temperature	-55	150	°C
Junction Temperature		150	°C
Storage Temperature	-60	150	°C

Over operating free-air temperature range (unless otherwise noted). Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device.

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## ESD Ratings

		Value	UNIT
Electrostatic Discharge	Human Body Mode (HBM), per ANSI/ESDA/JEDEC JS-001	±5000	V
	Machine Mode (MM), per JEDEC-STD Classification	300	V

## Recommended Operating Conditions

	MIN	NOM	MAX	UNIT
Supply Voltage V <sub>+</sub>	1.4	1.8	5.5	V
Operating Temperature T <sub>A</sub>	- 40		125	°C

Over operating free-air temperature range (unless otherwise noted).

## Electrical Characteristics

At T<sub>A</sub> = -40°C ~ +125°C and V<sub>+</sub> = 1.4 V ~ 5.5 V, unless otherwise noted. Typical values at T<sub>A</sub> = 25°C and V<sub>+</sub> = 1.8V.

PARAMETER	TEST CONDITONS	MIN	TYP	MAX	UNIT
Operating Temperature Range		-40		125	°C
Temperature Accuracy (Error)	+25°C, V <sub>+</sub> = 1.8V		±0.1	±0.5	°C
	0°C to +70°C, V <sub>+</sub> = 1.8V		±0.25	±0.5	°C
	-40°C to +125°C		±0.5	±1	°C
Supply Voltage Sensitivity	-40°C to +125°C		0.0625	±0.25	°C/V
Resolution			0.0625		°C
			12		Bits
Conversion Time	One-Shot Mode		26	35	ms
Conversion Rate			12		Conv/s
Bus Timeout Time			22	40	ms
Communication Frequency	Fast-Mode	0.001		0.4	MHz
	High-speed mode	0.001		2.75	
Power Supply Voltage		1.4	1.8	5.5	V
Average Quiescent Current, I <sub>Q</sub>	Serial bus inactive		15	37	μA
	Serial bus inactive, fSCL=400 kHz		25		
	Serial bus inactive, fSCL=2.75 MHz		95		
Shutdown Current, I <sub>SD</sub>	Serial bus inactive		0.5	1	μA
	Serial bus inactive, fSCL =400 kHz		10		
	Serial bus inactive, fSCL =2.75 MHz		80		

## 1.8V Digital Temperature Sensor with I<sup>2</sup>C Interface and Alarm Function

### Detailed Description

#### Temperature Output

The 12-bit digital output for each temperature measurement is stored in a read-only temperature sensor. Obtaining this output requires reading out two bytes, as shown in Table 5. Where byte 1 is the most significant byte (MSB), followed by byte 2 is the less significant byte (LSB), and the left-aligned upper 12 bits are used to indicate the temperature. If less than 1°C temperature resolution is not required, the user can choose not to read byte 2.

The data format of the TMP75 temperature measurement results is listed in Table 1, where 1LSB = 0.0625°C, and negative numbers are represented in two's complement.

When powered on or reset, the temperature register of the TMP75 will be set to 0000h until the next temperature conversion is completed. Unused bits in the temperature register always read as 0 (not shown in the table below).

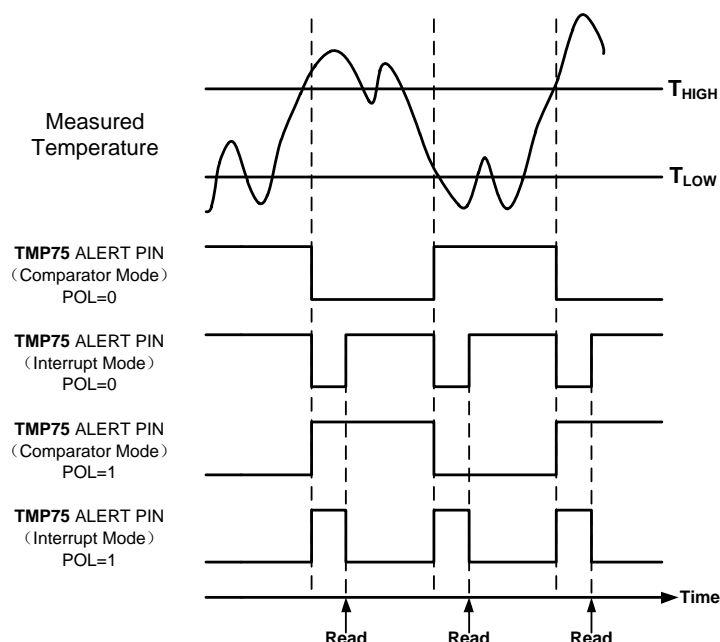
**Table 1. Temperature Data Format**

TEMPERATURE (°C)	DIGITAL OUTPUT (BINARY)	DIGITAL OUTPUT (HEX)
128	0111 1111 1111	7FF
127.9375	0111 1111 1111	7FF
100	0110 0100 0000	640
80	0101 0000 0000	500
75	0100 1011 0000	4B0
50	0011 0010 0000	320
25	0001 1001 0000	190
0.25	0000 0000 0100	004
0	0000 0000 0000	000
-0.25	1111 1111 1100	FFC
-25	1110 0111 0000	E70
-55	1100 1001 0000	C90

Note: Table 1 does not provide data formats for all temperatures.

## Over-Temperature Alarm

The users can choose to write the TM bit in the configuration register as 0 or 1, so as to configure the TMP75 in the Comparator Mode or Interrupt Mode to achieve different alarm functions.



**Figure 1. Status of the ALERT Pin in Different Modes**

In comparator mode (TM = 0, default), the ALERT pin becomes active when the temperature is equal to or exceeds the value in  $T_{HIGH}$  (fault conditions) for a consecutive number of conversions as set by the FQ bits of the configuration register. ALERT clears when the temperature falls below  $T_{LOW}$  for the same consecutive number of conversions. The difference between the two limits acts as a hysteresis on the comparator output, and a fault counter prevents false alerts as a result of environmental noise.

In interrupt mode (TM = 1), the ALERT pin becomes active when the temperature equals or exceeds the value in  $T_{HIGH}$  for a consecutive number of fault conditions. The ALERT pin remains active until a read operation of any register occurs. After the ALERT pin is cleared, this pin becomes active again only when temperature falls below  $T_{LOW}$  for a consecutive number of fault conditions, and remains active until cleared by a read operation of any register. The cycle repeats with the ALERT pin becoming active when the temperature equals or exceeds  $T_{HIGH}$ , and so on. The ALERT pin is cleared also when the device is placed in shutdown mode. This action also clears the fault counter memory.

The active state of the ALERT pin is set by the POL bit in the configuration register. When POL = 0 (default), the ALERT pin is active low. When POL = 1, the ALERT pin is active high. The operation of the ALERT pin in the various modes is illustrated in Figure 1.

### Serial Interface

#### Bus Overview

The device that initiates the transfer is called a master, and the devices controlled by the master are slaves. The bus must be controlled by a master device that generates the serial clock (SCL), controls the bus access, and generates the start and stop conditions.

To address a specific device, initiate a start condition by pulling the data line (SDA) from a high to a low logic level while SCL is high. All slaves on the bus shift in the slave address byte; the last bit indicates whether a read or write operation follows. During the ninth clock pulse, the slave being addressed responds to the master by generating an acknowledge bit and pulling SDA low.

Data transfer is then initiated and sent over eight clock pulses followed by an acknowledge bit. During data transfer, SDA must remain stable while SCL is high because any change in SDA while SCL is high is interpreted as a start or stop signal.

After all data have been transferred, the master generates a stop condition indicated by pulling SDA from low to high, while SCL is high.

#### Serial Bus Address

To communicate with the TMP75, the master must first communicate with slave devices using a slave address byte. The slave address byte consists of seven address bits, and a direction bit indicating the intent of executing either a read or write operation. The TMP75 features three address pins that allow up to eight devices to be addressed on a single bus. Table 2 describes the pin logic levels and the corresponding address values.

**Table 2. Address Pin Connections and Slave Addresses**

SLAVE ADDRESS	A2	A1	A0
1001000	GND	GND	GND
1001001	GND	GND	V+
1001010	GND	V+	GND
1001011	GND	V+	V+
1001100	V+	GND	GND
1001101	V+	GND	V+
1001110	V+	V+	GND
1001111	V+	V+	V+

## Writing and Reading Operation

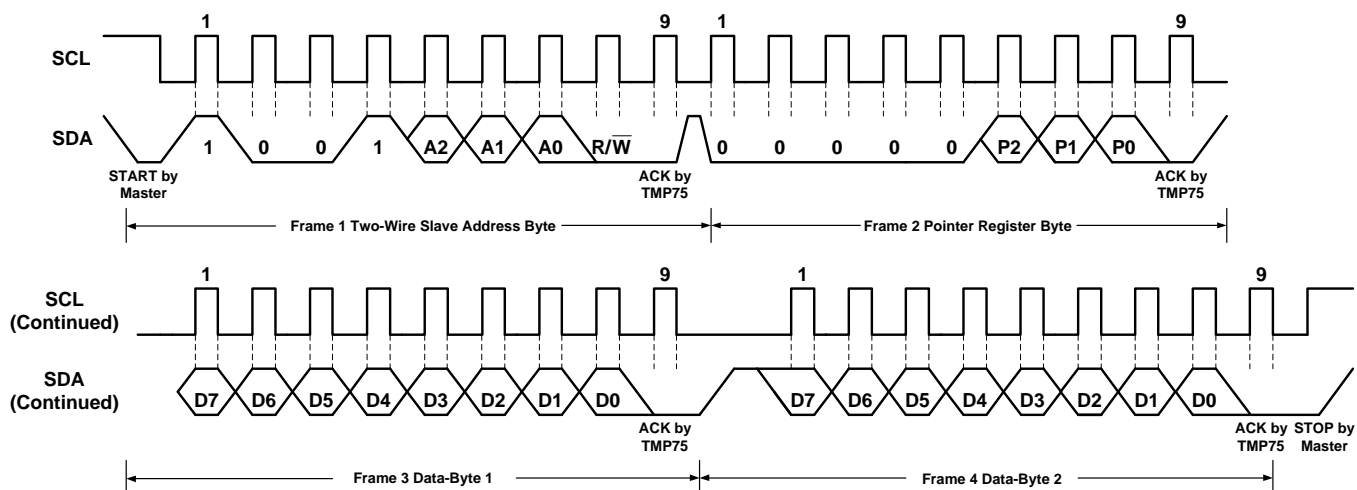


Figure 2. Two-wire Write Command Timing Diagram

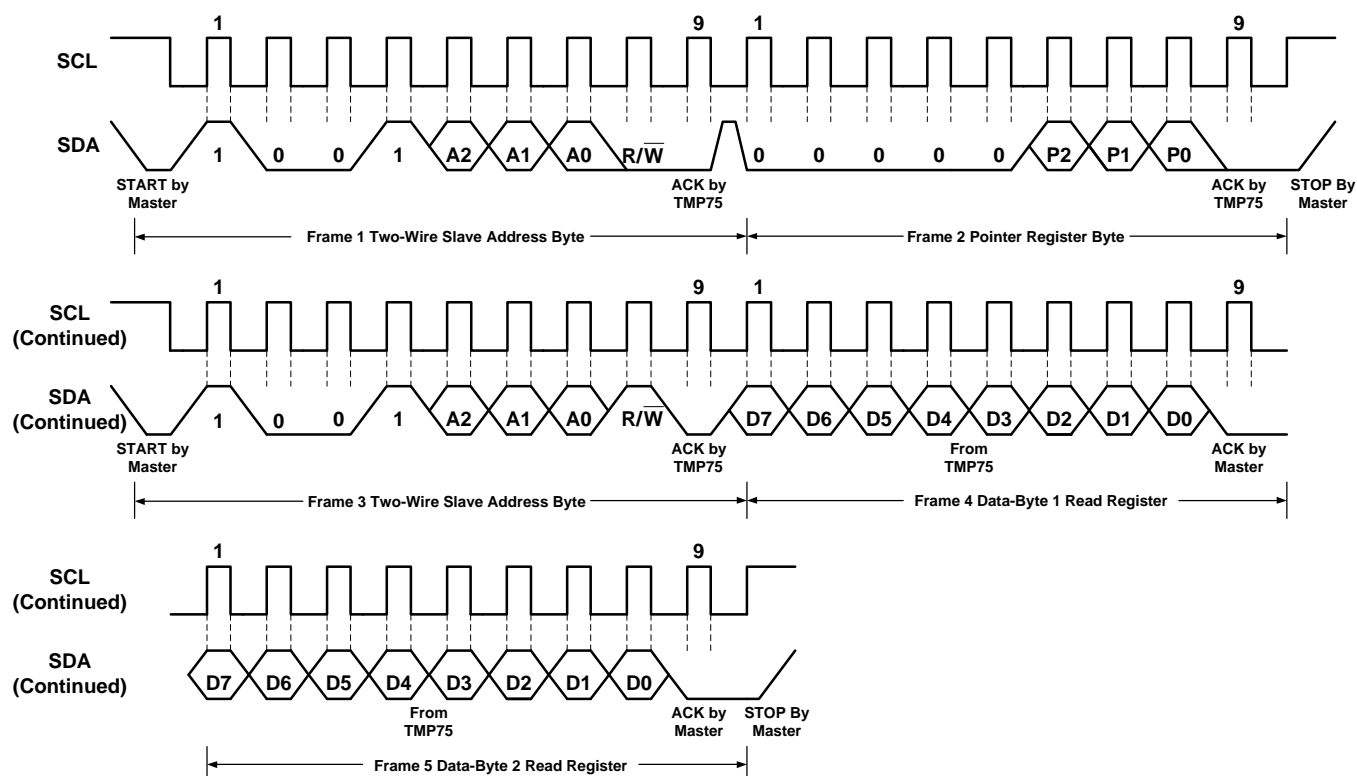


Figure 3. Two-wire Read Command Timing Diagram

## 1.8V Digital Temperature Sensor with I<sup>2</sup>C Interface and Alarm Function

Accessing a particular register on the TMP75 is accomplished by writing the appropriate value to the pointer register. The value for the pointer register is the first byte transferred after the slave address byte with the R/W bit low. Every write operation to the TMP75 requires a value for the pointer register (see Figure 2).

When reading from the TMP75, the last value stored in the pointer register by a write operation is used to determine which register is read by a read operation. To change the register pointer for a read operation, a new value must be written to the pointer register. This action is accomplished by issuing a slave address byte with the R/W bit low, followed by the pointer register byte. No additional data are required. The master can then generate a start condition and send the slave address byte with the R/W bit high to initiate the read command. See Figure 3 for details of this sequence. If repeated reads from the same register are desired, there is no need to continually send the pointer register bytes because the TMP75 stores the pointer register value until it is changed by the next write operation.

Note that register bytes are sent with the most significant byte first, followed by the least significant byte.

### High-Speed Mode

In order for the I<sup>2</sup>C bus to operate at frequencies above 400 kHz, the master device must issue an Hs-mode code (00001xxx) as the first byte after a start condition to switch the bus to high-speed operation. The TMP75 does not acknowledge this byte, but does switch its input filters on SDA and SCL and its output filters on SDA to operate in Hs-mode, allowing transfers at up to 2.75 MHz. After the Hs-mode code has been issued, the master transmits a slave address to initiate a data-transfer operation. The bus continues to operate in Hs-mode until a stop condition occurs on the bus. Upon receiving the stop condition, the TMP75 switches the input and output filters back to fast-mode operation.

### Time-Out Function

The TMP75 resets the serial interface if SCL or SDA are held low for 22 ms (typ) between a start and stop condition. If the TMP75 is pulled low, it releases the bus and then waits for a start condition. To avoid activating the timeout function, it is necessary to maintain a communication speed of at least 1 kHz for the SCL operating frequency.



## Functional Modes

### Continuous Mode

The default mode of the TMP75 is continuous conversion, where the ADC performs continuous temperature conversions and stores each result to the Temperature register, overwriting the result from the previous conversion. The typical conversion rate of TMP75 is 12 Hz, with 80 ms between the start of each consecutive conversion. The TMP75 has a typical conversion time of 26 ms. To achieve its conversion rates, the TMP75 makes a conversion, and then powers down and waits for a delay 54 ms.

After power-up, the TMP75 immediately starts a conversion, as shown in Figure 4. The first result is available after 26 ms (typical). The active quiescent current during conversion is 40  $\mu$ A (typical at +25°C). The quiescent current during delay is 2.2  $\mu$ A (typical at +25°C).

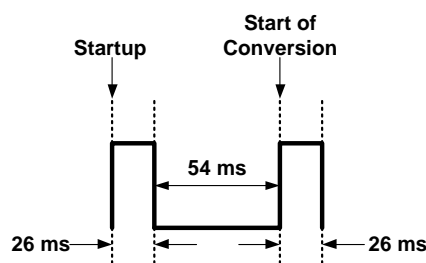


Figure 4. Conversion Diagram

### Shutdown Mode

The shutdown mode saves maximum power by shutting down all device circuitry other than the serial interface, and reduces current consumption to typically less than 0.5  $\mu$ A. Shutdown mode is enabled when the SD bit in the configuration register is set to 1; the device shuts down and terminates a conversion if it is ongoing. When SD is equal to 0, the device operates in continuous-conversion mode. When shutdown mode is enabled, the ALERT pin and fault counter clear in both comparator and interrupt modes. The ALERT pin and the fault counter remain clear until the SD bit is set.

### One-Shot Mode

The TMP75 features a one-shot temperature measurement mode. When the device is in continuous conversion (SD = 0), writing a 1 to the OS bit enables shutdown mode, where any write to the one-shot register triggers a single temperature conversion. The device returns to the shutdown state at the completion of the single conversion, and a subsequent write to the one-shot register triggers another single conversion followed by a return to shutdown state. This mode reduces power consumption in the TMP75 when continuous temperature monitoring is not required.

When the device is in complete shutdown (SD = 1), the one-shot mode is not active regardless of the state of the OS bit, and a write to the one-shot register has no effect.

## Register Map

Figure 5 shows the internal register structure of the TMP75. Use the 8-bit pointer register to address a given data register. The pointer register uses the three LSBs to identify which of the data registers respond to a read or write command. Table 4 identifies the bits of the pointer register byte.

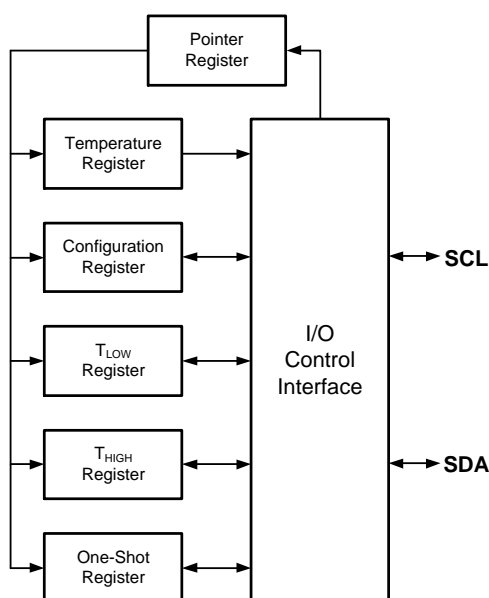


Figure 5. Internal Register Structure

Table 3. Pointer Address

P2	P1	P0	REGISTER
0	0	0	Temperature Register (read only)
0	0	1	Configuration Register (read/write)
0	1	0	T <sub>LOW</sub> Register (read/write)
0	1	1	T <sub>HIGH</sub> Register (read/write)
1	0	0	One-Shot Register (write only; write any value to start a conversion)

Table 4. Pointer Register Byte (reset=00h)

7	6	5	4	3	2	1	0
Reserved					P2	P1	P0
W-0h					W-0h	W-0h	W-0h

LEGEND: R/W=Read/Write; R=Read only; W=Write only; -n=value after reset

**1.8V Digital Temperature Sensor with I<sup>2</sup>C Interface and Alarm Function**
**Table 5. Temperature Register (pointer=0h) (reset=0000h)**

<b>15</b>	<b>14</b>	<b>13</b>	<b>12</b>	<b>11</b>	<b>10</b>	<b>9</b>	<b>8</b>
T11	T10	T9	T8	T7	T6	T5	T4
R-00h							
<b>7</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
T3	T2	T1	T0	Reserved			
R-0h				R-0h			

LEGEND: R/W=Read/Write; R=Read only; W=Write only; -n=value after reset

**Table 6. Temperature Register Description**

Field	Description
T11 ~ T4	The 8 MSBs of the temperature result (resolution of 1°C)
T3 ~ T0	The 4 LSBs of the temperature result (resolution of 0.0625°C)

**Table 7. T<sub>HIGH</sub> Register (pointer=2h) (reset=5000h) <sup>[1]</sup>**

<b>15</b>	<b>14</b>	<b>13</b>	<b>12</b>	<b>11</b>	<b>10</b>	<b>9</b>	<b>8</b>
H11	H10	H9	H8	H7	H6	H5	H4
R/W-50h							
<b>7</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
H3	H2	H1	H0	Reserved			
R/W-0h				R-0h			

LEGEND: R/W=Read/Write; R=Read only; W=Write only; -n=value after reset

[1] 5000h = +80°C

**Table 8. T<sub>LOW</sub> Register (pointer=3h) (reset=4B00h) <sup>[2]</sup>**

<b>15</b>	<b>14</b>	<b>13</b>	<b>12</b>	<b>11</b>	<b>10</b>	<b>9</b>	<b>8</b>
L11	L10	L9	L8	L7	L6	L5	L4
R/W-4Bh							
<b>7</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
L3	L2	L1	L0	Reserved			
R/W-0h				R-0h			

LEGEND: R/W=Read/Write; R=Read only; W=Write only; -n=value after reset

[2] 4B00h = +75°C

**1.8V Digital Temperature Sensor with I<sup>2</sup>C Interface and Alarm Function**
**Table 9. Configuration Register (pointer=1h) (reset=0000h)**

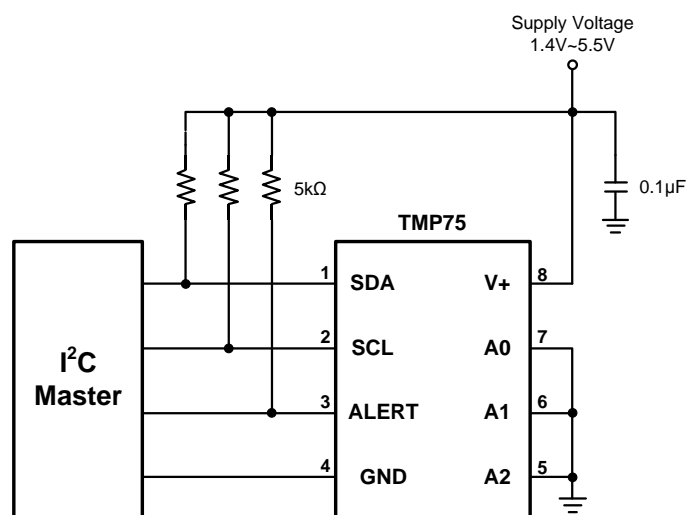
15	14	13	12	11	10	9	8
Reserved		OS	FQ		POL	TM	SD
R-00h		R/W-0h	R/W-0h		R/W-0h	R/W-0h	R/W-0h
7	6	5	4	3	2	1	0
Reserved							
R-00h							

LEGEND: R/W=Read/Write; R=Read only; W=Write only; -n=value after reset

**Table 10. Configuration Register Description**

Field	Description
OS	One-Shot control SD=0 & OS=0 : continuous mode (default) SD=0 & OS=1 : one-shot mode; writing any value to the one-shot register initiates a conversion. SD=1 & OS=x : shutdown mode; the status of the OS bit has no effect.
FQ	Fault queue to trigger the ALERT pin FQ=0h : 1 fault (default) FQ=1h : 2 fault FQ=2h : 4 fault FQ=3h : 6 fault
POL	ALERT polarity control POL=0 : ALERT is active low (default) POL=1 : ALERT is active high
TM	ALERT thermostat mode control TM=0 : ALERT is in comparator mode (default) TM=1 : ALERT is in interrupt mode
SD	Shutdown control SD=0 : Device is in continuous mode (default) SD=1 : Device is in shutdown mode

## Application and Implementation



**Figure 6. Typical Connections of the TMP75**

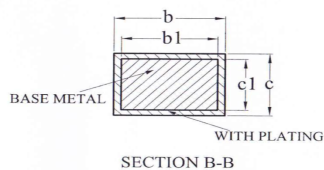
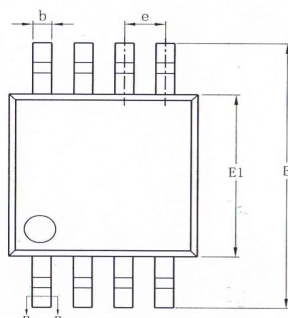
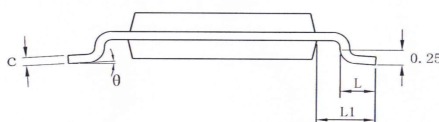
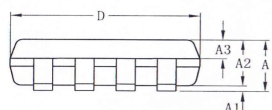
The TMP75 only requires pull-up resistors on SDA and ALERT, although a pull-up resistor is typically present on the SCL as well. A 0.1-μF bypass capacitor on the supply is recommended, as shown in Figure 6. The SCL, SDA, and ALERT lines can be pulled up to a supply that is equal to or higher than V+ through the pull-up resistors. To configure one of eight different addresses on the bus, connect A0, A1, and A2 to either V+ or GND.

The TMP75 should be placed in close proximity to the heat source to be monitored, with a proper layout for good thermal coupling. This ensures that temperature changes are captured within the shortest possible time interval. To maintain accuracy in applications that require air or surface temperature measurement, take care to isolate the package and leads from ambient air temperature. A thermally-conductive adhesive is helpful in achieving accurate surface temperature measurement.

# 1.8V Digital Temperature Sensor with I<sup>2</sup>C Interface and Alarm Function

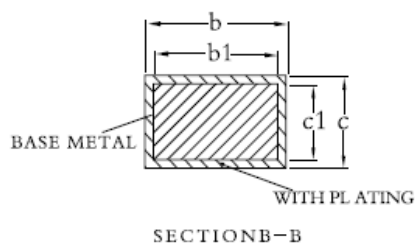
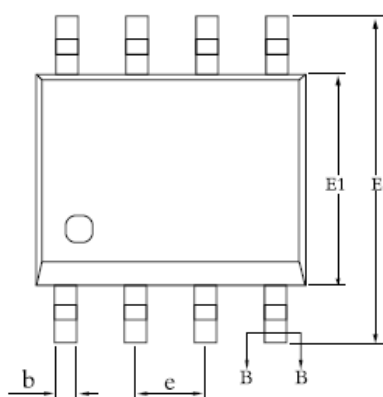
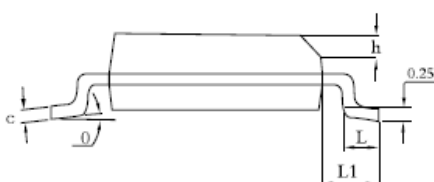
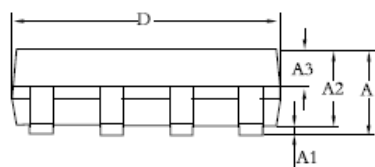
## Packaging information

### MSOP-8



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.10
A1	0.05	—	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0.40
b	0.28	—	0.36
b1	0.27	0.30	0.33
c	0.15	—	0.19
c1	0.14	0.15	0.16
D	2.90	3.00	3.10
E	4.70	4.90	5.10
E1	2.90	3.00	3.10
e	0.65BSC		
L	0.40	—	0.70
L1	0.95REF		
θ	0	—	8°

### SOP-8



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.75
A1	0.10	—	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.75
b	0.39	—	0.48
b1	0.38	0.41	0.43
c	0.21	—	0.26
c1	0.19	0.20	0.21
D	4.79	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
h	0.25	—	0.50
L	0.50	—	0.80
L1	1.05BSC		
θ	0	—	8°
L/F 载体尺寸 (mil)	80*80	90*90	95*130

## Ordering information

Order code	Package	Baseqty	Deliverymode	Marking
UMW TMP75AIDR	SOP-8	4000	Tape and reel	TMP75
UMW TMP75AIDGKR	MSOP-8	4000	Tape and reel	TMP75