采用 SOT563 封装、具有 SMBus 和双线制串行接口的 TMP102 低功耗数字温度传感器

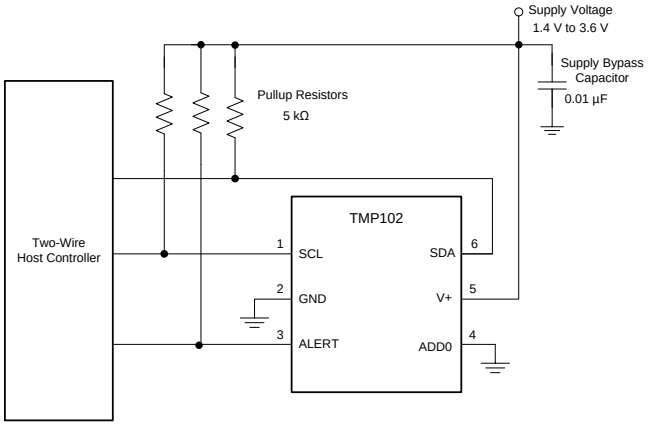
1 特性

- SOT563 封装 (1.6mm × 1.6mm) 相较于 SOT-23，尺寸缩小了 68%
- 未经校准时的精度：
  - –25°C 至 85°C 范围内为 2.0°C（最大值）
  - –40°C 至 125°C 范围内为 3.0°C（最大值）
- 低静态电流:
  - 激活时 10μA（最大值）
  - 关断时 1μA（最大值）
- 电源电压范围：1.4V 至 3.6V
- 分辨率：12 位
- 数字输出：兼容 SMBus、双线制和 I²C 接口
- NIST 可追溯

2 应用

- 便携式和电池供电类 应用
- 电源温度监控
- 计算机外设过热保护
- 笔记本电脑
- 电池管理
- 办公机器
- 恒温器控制
- 机电设备温度
- 通用温度测量：
  - 工业控制
  - 测试设备
  - 医疗仪表

简化电路原理图



3 说明

TMP102 器件是一款数字温度传感器，非常适用于作为需要高精度的 NTC/PTC 热敏电阻的替代品。该器件在未经校准或无外部组件信号调节的情况下可提供的精度为 ±0.5°C。器件温度传感器为高度线性化产品，无需复杂计算或查表即可得知温度。片上 12 位 ADC 具备最低 0.0625°C 的分辨率。

1.6mm × 1.6mm 的 SOT563 封装相较于 SOT-23 封装，尺寸缩小了 68%。TMP102 器件 具备 SMBus ™、两线制和 I²C 接口兼容性，最多允许四个器件位于一条总线上。此外，该器件还 具备 SMBus 报警功能。器件的额定工作电压范围是 1.4V 至 3.6V，整个工作范围内最大静态电流为 10μA。

TMP102 器件适用于在各种通信、计算机、消费类产品、环境、工业和仪表 应用中进行扩展温度测量。器件的额定工作温度范围为 –40°C 至 125°C。

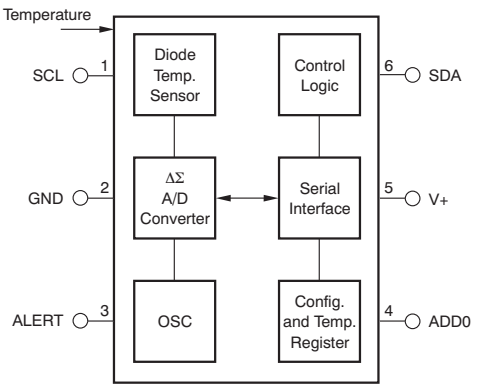
TMP102 生产单元已经过 100% 的传感器测试，具有 NIST 可追溯的特点，并已借助 NIST 可追溯的设备使用 ISO/IEC 17025 标准认可的校准要求进行验证。

器件信息(1)

器件型号	封装	封装尺寸（标称值）
TMP102	SOT563 (6)	1.60mm x 1.20mm

(1) 如需了解所有可用封装，请参阅产品说明书末尾的可订购产品附录。

方框图



目录

4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

Changes from Revision G (September 2018) to Revision H — **Page**

- Changed *Absolute Maximum Ratings* for voltage at SCL, SDA and ADD0 pin ... 4
- Changed *Absolute Maximum Ratings* for voltage at ALERT pin ... 4

Changes from Revision F (September 2018) to Revision G — **Page**

- Changed input voltage maximum value from: 3.6 V to: 4 V ... 4
- Changed output voltage maximum value from: 3.6 V to: ((V+) + 0.5) and ≤ 4 V ... 4
- Changed Junction-to-ambient thermal resistance from 200 °C/W to 210.3 °C/W ... 5
- Changed Junction-to-case (top) thermal resistance from 73.7 °C/W to 105.0 °C/W ... 5
- Changed Junction-to-board thermal resistance from 34.4 °C/W to 87.5 °C/W ... 5
- Changed Junction-to-top characterization parameter from 3.1 °C/W to 6.1 °C/W ... 5
- Changed Junction-to-board characterization parameter from 34.2 °C/W to 87.0 °C/W ... 5
- 添加了*接收文档更新通知* 部分 ... 24

Changes from Revision E (April 2015) to Revision F — **Page**

- 添加了 TI 设计 ... 1
- 添加 NIST 特性 要点 ... 1
- *说明* 部分的最后添加了一个段落 ... 1

Changes from Revision D (December 2014) to Revision E — **Page**

- Changed the MAX value for the Supply voltage from 3.6 to 4 in the *Absolute Maximum Ratings* table ... 4
- Changed MIN, TYP, and MAX values for the Temperature Accuracy (temperature error) parameter ... 5
- Changed the frequency from 2.85 to 3.4 MHz in the POWER SUPPLY section of the *Electrical Characteristics* table ... 6
- Changed the Temperature Error vs Temperature graph in the *Typical Characteristics* section ... 7

- Changed the Temperature Error at 25°C graph in the *Typical Characteristics* section 7

Changes from Revision C (October 2012) to Revision D **Page**

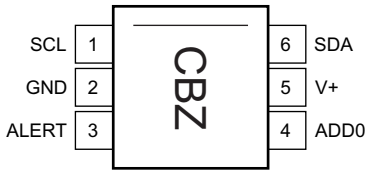
- Added *Handling Rating* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 4
- Changed parameters in *Timing Requirements* 6

Changes from Revision B (October 2008) to Revision C **Page**

- Changed values for *Data Hold Time parameter* in *Timing Requirements* 12

5 Pin Configuration and Functions

DRL Package
6-Pin SOT563
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	SCL	I	串行时钟。 开漏输出； 需要一个上拉电阻。
2	GND	—	Ground
3	ALERT	O	超温警报。 开漏输出； 需要一个上拉电阻。
4	ADD0	I	地址选择。 连接到GND 或V+
5	V+	I	电源电压，1.4V 至3.6V
6	SDA	I/O	串行数据。 开漏输出； 需要一个上拉电阻。

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

	MIN	MAX	UNIT
Supply Voltage		4	V
Voltage at SCL, SDA and ADD0(2)	–0.5	4	V
Voltage at ALERT		((V+) + 0.3) and ≤ 4	V
Operating temperature	–55	150	°C
Junction temperature		150	°C
Storage temperature, T_{stg}	–60	150	°C

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not supported.
(2) Input voltage rating applies to all TMP102 input voltages.

6.2 Handling Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±1000	
		Machine model (MM)	±200	

(1) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) Level listed above is the passing level per EIA-JEDEC JESD22-C101. JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V+	Supply voltage	1.4	3.3	3.6	V
T_A	Operating free-air temperature	–40		125	°C

6.4 Thermal Information

THERMAL METRIC(1)		TMP102 DRL (SOT563) 6 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	210.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	105.0	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	87.5	°C/W
ψ_{JT}	Junction-to-top characterization parameter	6.1	°C/W
ψ_{JB}	Junction-to-board characterization parameter	87.0	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report (SPRA953).

6.5 Electrical Characteristics

At T_A = 25°C and V_S = 1.4 to 3.6 V, unless otherwise noted.

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
TEMPERATURE INPUT							
	Range			–40		125	°C
	Accuracy (temperature error)		–25°C to 85°C		±0.5	±2	°C
			–40°C to 125°C		±1	±3	
	vs supply				0.2	0.5	°C/V
	Resolution				0.0625		°C
DIGITAL INPUT/OUTPUT							
	Input capacitance				3		pF
V_{IH}	Input logic high			0.7 × (V+)		3.6	V
V_{IL}	Input logic low			–0.5		0.3 × (V+)	V
I_{IN}	Input current		0 < V_{IN} < 3.6 V			1	µA
V_{OL}	Output logic	SDA	V+ > 2 V, I_{OL} = 3 mA	0		0.4	V
			V+ < 2 V, I_{OL} = 3 mA	0		0.2 × (V+)	
		ALERT	V+ > 2 V, I_{OL} = 3 mA	0		0.4	
			V+ < 2 V, I_{OL} = 3 mA	0		0.2 × (V+)	
	Resolution				12		Bit
	Conversion time				26	35	ms
	Conversion modes		CR1 = 0, CR0 = 0		0.25		Conv/s
			CR1 = 0, CR0 = 1		1		
			CR1 = 1, CR0 = 0 (default)		4		
			CR1 = 1, CR0 = 1		8		
	Timeout time				30	40	ms

Electrical Characteristics (continued)

At T_A = 25°C and V_S = 1.4 to 3.6 V, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
	Operating supply range		+1.4		+3.6	V
I_Q	Average quiescent current	Serial bus inactive, CR1 = 1, CR0 = 0 (default)		7	10	µA
		Serial bus active, SCL frequency = 400 kHz		15		
		Serial bus active, SCL frequency = 3.4 MHz		85		
I_{SD}	Shutdown current	Serial bus inactive		0.5	1	µA
		Serial bus active, SCL frequency = 400 kHz		10		
		Serial bus active, SCL frequency = 3.4 MHz		80		
TEMPERATURE						
	Specified range		–40		125	°C
	Operating range		–55		150	°C

6.6 Timing Requirements

See the *Timing Diagrams* section for additional information.

			FAST MODE			HIGH-SPEED MODE			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$f_{(SCL)}$	SCL operating frequency	V+	0.001		0.4	0.001		2.85	MHz
$t_{(BUF)}$	Bus-free time between STOP and START condition	See Figure 7	600			160			ns
$t_{(HDSTA)}$	Hold time after repeated START condition. After this period, the first clock is generated.		600			160			ns
$t_{(SUSTA)}$	repeated start condition setup time		600			160			ns
$t_{(SUSTO)}$	STOP condition setup time		600			160			ns
$t_{(HDDAT)}$	Data hold time		100		900	25		105	ns
$t_{(SUDAT)}$	Data setup time		100			25			ns
$t_{(LOW)}$	SCL-clock low period	V+ , see Figure 7	1300			210			ns
$t_{(HIGH)}$	SCL-clock high period	See Figure 7	600			60			ns
t_{FD}	Data fall time	See Figure 7			300			80	ns
t_{RD}	Data rise time	See Figure 7			300				ns
		SCLK ≤ 100 kHz, see Figure 7			1000				ns
t_{FC}	Clock fall time	See Figure 7			300			40	ns
t_{RC}	Clock rise time	See Figure 7			300			40	ns

6.7 Typical Characteristics

At T_A = 25°C and V+ = 3.3 V, unless otherwise noted.

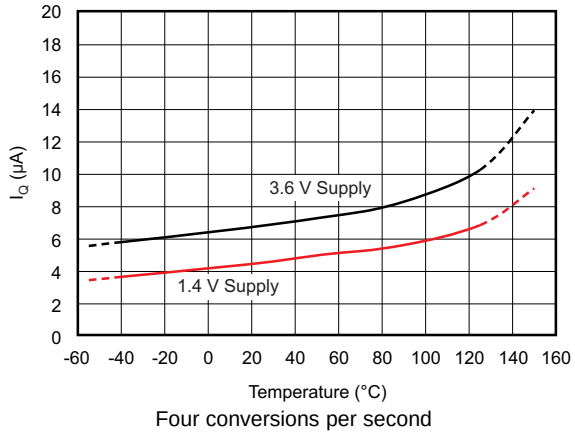


Figure 1. Average Quiescent Current vs Temperature

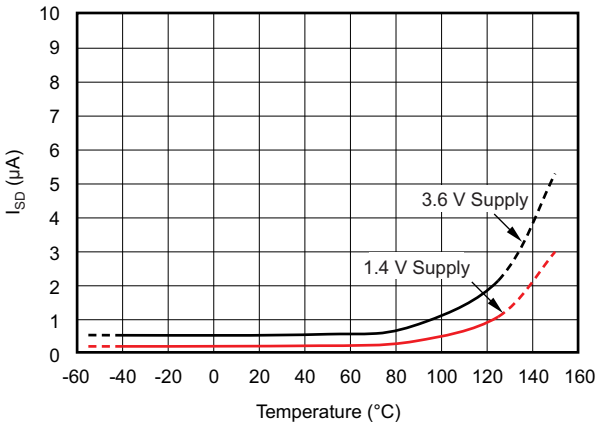


Figure 2. Shutdown Current vs Temperature

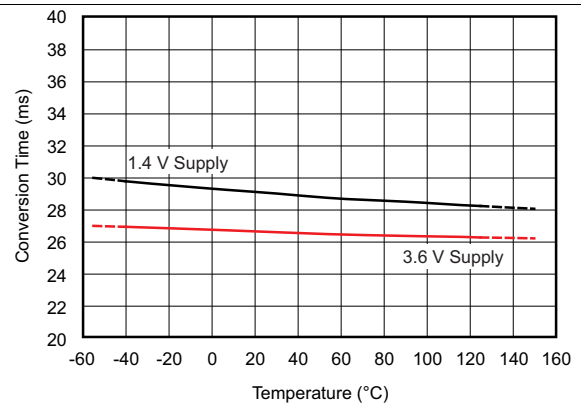


Figure 3. Conversion Time vs Temperature

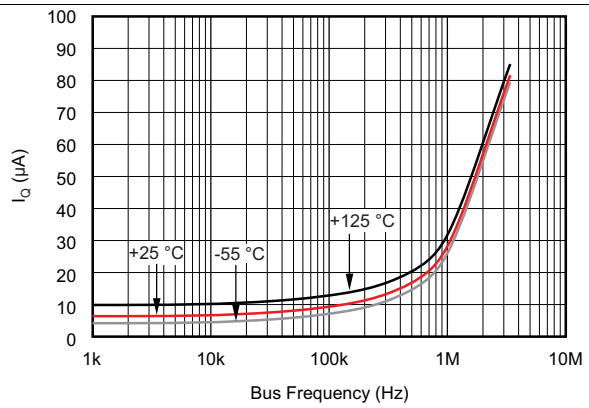


Figure 4. Quiescent Current vs Bus Frequency (Temperature at 3.3-V Supply)

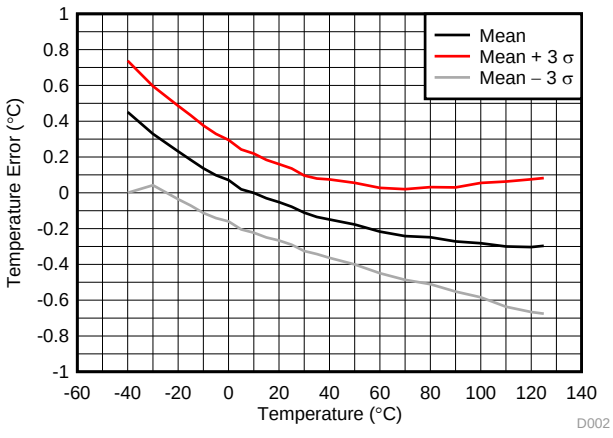


Figure 5. Temperature Error vs Temperature

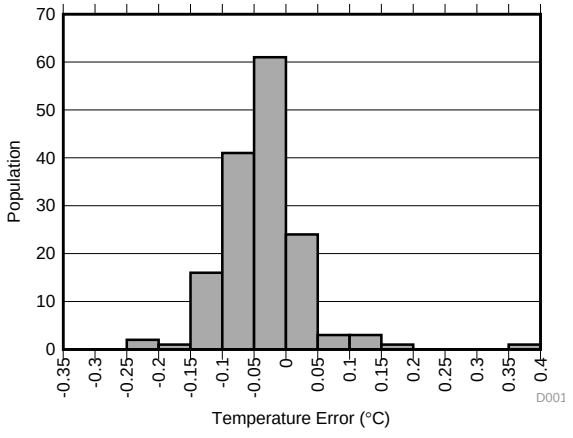


Figure 6. Temperature Error at 25°C

7 Detailed Description

7.1 概述

TMP102 器件是一种数字温度传感器，最适合热管理和热保护应用。TMP102 器件是两线、SMBus 和I2C 接口兼容的。 该器件的额定工作温度范围为–40°C 至125°C 。 有关TMP102 器件的框图，请参见功能框图。

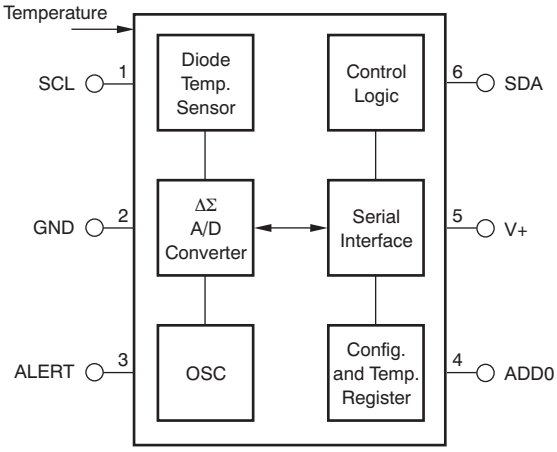
TMP102 器件中的温度传感器是芯片本身。 热路径穿过封装引线以及塑料封装。 由于金属的热阻较低，封装引线提供了主要的热路径。

可以使用TMP102 器件的替代版本。TMP112 器件精度最高，采用相同的微型封装，并且引脚兼容。

Table 1. Advantages of TMP112 versus TMP102

DEVICE	COMPATIBLE INTERFACES	PACKAGE	SUPPLY CURRENT	SUPPLY VOLTAGE (MIN)	SUPPLY VOLTAGE (MAX)	RESOLUTION	LOCAL SENSOR ACCURACY (MAX)	SPECIFIED CALIBRATION DRIFT SLOPE
TMP112	I^2C SMBus	SOT563 1.2 × 1.6 × 0.6	10 µA	1.4 V	3.6 V	12 bit 0.0625°C	0.5°C: (0°C to 65°C) 1°C: (-40°C to 125°C)	Yes
TMP102	I^2C SMBus	SOT563 1.2 × 1.6 × 0.6	10 µA	1.4 V	3.6 V	12 bit 0.0625°C	2°C: (25°C to 85°C) 3°C: (-40°C to 125°C)	No

7.2 Functional Block Diagram



7.3 功能描述

7.3.1 数字温度输出

每个温度测量的数字输出存储在只读温度寄存器中。 TMP102 器件的温度寄存器配置为 12 位只读寄存器（配置寄存器 EM 位 = 0，请参阅扩展模式 (EM) 部分），或配置为 13 位只读寄存器（配置寄存器 EM 位 = 1) 存储最近转换的输出。必须读取两个字节才能获取数据，表 8 和表 9 中列出了这些字节。字节 1 是最高有效字节 (MSB)，随后是字节 2，最低有效字节 (LSB)。前 12 位（扩展模式下为 13 位）用于指示温度。如果不需要该信息，则不必读取最低有效字节。温度的数据格式总结在表 2 和表 3 中。一个 LSB 等于 0.0625°C。负数以二进制补码格式表示。上电或复位后，温度寄存器读数为 0°C，直到第一次转换完成。字节 2 的 D0 位表示正常模式（EM 位 = 0）或扩展模式（EM 位=1 ），可用于区分两种温度寄存器数据格式。温度寄存器中未使用的位始终为0 。

Feature Description (continued)

Table 2. 12-Bit Temperature Data Format(1)

温度 (°C)	DIGITAL OUTPUT (BINARY)	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

(1) 内部温度模式下温度ADC 的分辨率为0.0625°C/ 计数。

表2 并未列出所有温度。 使用以下规则获取给定温度的数字数据格式或给定数字数据格式的温度。
要将正温度转换为数字数据格式：

1. 温度除以分辨率
2. 将结果转换为 12 位左对齐格式的二进制代码，MSB = 0 表示正号。 示例：(50°C) / (0.0625°C / LSB) = 800 = 320h = 0011 0010 0000

要将正数字数据格式转换为温度：

1. 将12 位左对齐二进制温度结果（MSB=0 表示正号）转换为十进制数。
2. 十进制数乘以分辨率得到正温度。

示例：0011 0010 0000 = 320h = 800 × (0.0625°C / LSB) = 50°C

要将负温度转换为数字数据格式：

1. 将温度的绝对值除以分辨率，将结果转换为二进制代码
12 位，左对齐格式。
2. 通过对二进制数求补并加一，生成结果的二进制补码。 用 MSB = 1 表示负数。

示例：(|–25°C|) / (0.0625°C / LSB) = 400 = 190h = 0001 1001 0000
二进制补码格式：1110 0110 1111 + 1 = 1110 0111 0000

要将负数字数据格式转换为温度：

1. 生成温度结果的12 位左对齐二进制数的二进制补码（MSB=1 ，表示负温度结果）通过对二进制数求反并加
1。 这表示温度绝对值的二进制数。
2. 转换为十进制数乘以分辨率得到绝对温度，然后乘以
–1 表示负号。

示例：1110 0111 0000 的补码为 0001 1001 0000 = 0001 1000 1111 + 1
转换为温度：000110010000=190h=400 ；400×(0.0625°C/LSB)=25°C=(|–25°C|);(|–25°C|)×(–1)=–25°C

Table 3. 13 位温度数据格式

TEMPERATURE (°C)	DIGITAL OUTPUT (BINARY)	HEX
150	0 1001 0110 0000	0960
128	0 1000 0000 0000	0800
127.9375	0 0111 1111 1111	07FF
100	0 0110 0100 0000	0640
80	0 0101 0000 0000	0500
75	0 0100 1011 0000	04B0
50	0 0011 0010 0000	0320
25	0 0001 1001 0000	0190
0.25	0 0000 0000 0100	0004
0	0 0000 0000 0000	0000
–0.25	1 1111 1111 1100	1FFC
–25	1 1110 0111 0000	1E70
–55	1 1100 1001 0000	1C90

7.3.2 串行接口

TMP102 器件仅在两线总线和 SMBus 上作为从器件运行。 通过开漏 I/O 线、SDA 和 SCL 连接到总线。 SDA 和 SCL 引脚具有集成尖峰抑制滤波器和施密特触发器，以最大限度地减少输入尖峰和总线噪声的影响。 TMP102 器件支持快速（1 kHz 至 400 kHz）和高速（1 kHz 至 2.85 MHz）模式的传输协议。 所有数据字节均以 MSB 为先传输。

7.3.3 Bus Overview

The device that initiates the transfer is called a *master*, and the devices controlled by the master are called *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, a START condition is initiated, indicated by pulling the data-line (SDA) from a high to low logic level when SCL is high. All slaves on the bus shift in the slave address byte on the rising edge of the clock, with the last bit indicating whether a read or write operation is intended. During the ninth clock pulse, the slave being addressed responds to the master by generating an acknowledge and by pulling SDA pin low.

A data transfer is then initiated and sent over eight clock pulses followed by an acknowledge bit. During the data transfer the SDA pin must remain stable when SCL is high, because any change in SDA pin when SCL pin is high is interpreted as a START signal or STOP signal.

When all data have been transferred, the master generates a STOP condition indicated by pulling SDA pin from low to high, when the SCL pin is high.

7.3.4 串行总线地址

To communicate with the TMP102, 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 TMP102 features an address pin to allow up to four devices to be addressed on a single bus. Table 4 describes the pin logic levels used to properly connect up to four devices.

Table 4. Address Pin and Slave Addresses

DEVICE TWO-WIRE ADDRESS	A0 PIN CONNECTION
1001000	Ground
1001001	V+
1001010	SDA
1001011	SCL

7.3.5 读写操作

通过将适当的值写入指针寄存器来访问TMP102 器件上的特定寄存器。指针寄存器的值是在R/W 位为低的从地址字节之后传输的第一个字节。对TMP102 器件的每次写操作都需要指针寄存器的值（参见图8 ）。

从TMP102 器件读取时，通过写操作存储在指针寄存器中的最后一个值决定了读操作读取的是哪个寄存器。要更改读取操作的寄存器指针，必须将新值写入指针寄存器。这个动作是通过发出一个R/W 位为低的从地址字节，然后是指针寄存器字节来完成的。不需要额外的数据。然后主机产生一个起始条件并发送具有R/W 位高电平的从机地址字节以启动读命令。有关此序列的详细信息，请参见图7 。如果需要从同一寄存器重复读取，则不需要连续发送指针寄存器字节，因为TMP102 会记住指针寄存器值，直到它被下一次写操作更改为止。

寄存器字节首先发送最高有效字节，然后是最低有效字节。

7.3.6 从模式操作

The TMP102 can operate as a slave receiver or slave transmitter. As a slave device, the TMP102 never drives the SCL line.

7.3.6.1 从接收器模式

The first byte transmitted by the master is the slave address, with the R/W bit low. The TMP102 then acknowledges reception of a valid address. The next byte transmitted by the master is the pointer register. The TMP102 then acknowledges reception of the pointer register byte. The next byte or bytes are written to the register addressed by the pointer register. The TMP102 acknowledges reception of each data byte. The master can terminate data transfer by generating a START or STOP condition..

7.3.6.2 从机模式

The first byte transmitted by the master is the slave address, with the R/W bit high. The slave acknowledges reception of a valid slave address. The next byte is transmitted by the slave and is the most significant byte of the register indicated by the pointer register. The master acknowledges reception of the data byte. The next byte transmitted by the slave is the least significant byte. The master acknowledges reception of the data byte. The master terminates data transfer by generating a *Not-Acknowledge* on reception of any data byte, or generating a START or STOP condition.

7.3.7 SMBus Alert Function

The TMP102 device supports the SMBus alert function. When the TMP102 device operates in Interrupt Mode (TM = 1), the ALERT pin can be connected as an SMBus alert signal. When a master senses that an ALERT condition is present on the ALERT line, the master sends an SMBus alert command (0001 1001) to the bus. If the ALERT pin is active, the device acknowledges the SMBus alert command and responds by returning the slave address on the SDA line. The eighth bit (LSB) of the slave address byte indicates if the ALERT condition was caused by the temperature exceeding T_{HIGH} or falling below T_{LOW}. For POL = 0, the LSB is low if the temperature is greater than or equal to T_{HIGH}; this bit is high if the temperature is less than T_{LOW}. The polarity of this bit is inverted if POL = 1. See Figure 10 for details of this sequence.

If multiple devices on the bus respond to the SMBus alert command, arbitration during the slave address portion of the SMBus alert command determines which device clears the ALERT status. The device with the lowest two-wire address wins the arbitration. If the TMP102 device wins the arbitration, its ALERT pin inactivates at the completion of the SMBus alert command. If the TMP102 device loses the arbitration, its ALERT pin remains active.

7.3.8 General Call

如果第 8 位为 0，则 TMP102 器件响应双线广播调用地址 (000 0000)。设备确认广播调用地址并响应第二个字节中的命令。 如果第二个字节是 0000 0110，则 TMP102 器件内部寄存器复位为上电值。 TMP102 器件不支持通用地址获取命令。

7.3.9 高速(HS) 模式

为了使两线总线以高于 400 kHz 的频率运行，主设备必须发出 HS 模式主代码 (0000 1xxx) 作为 START 条件后的第一个字节，以将总线切换到高速运行。 TMP102 器件不确认该字节，但将 SDA 和 SCL 上的输入滤波器以及 SDA 上的输出滤波器切换为以 HS 模式运行，从而允许高达 2.85 MHz 的传输。 发出 HS 模式主机代码后，主机发送两线从机地址以启动数据传输操作。 总线继续在 HS 模式下运行，直到总线上出现 STOP 条件。 收到停止条件后，TMP102 器件将输入和输出滤波器切换回快速模式操作。

7.3.10 超时功能

The TMP102 device resets the serial interface if SCL is held low for 30 ms (typ) between a start and stop condition. The TMP102 device releases the SDA line if the SCL pin is pulled low and waits for a start condition from the host controller. To avoid activating the time-out function, maintaining a communication speed of at least 1 kHz for SCL operating frequency is necessary..

7.3.11 时序图

The TMP102 device is two-wire, SMBus, and I^2C-interface compatible. Figure 7, Figure 8, Figure 9, and Figure 10 list the various operations on the TMP102 device. Parameters for Figure 7 are defined in the *Timing Requirements* table. The bus definitions are defined as follows:

Acknowledge Each receiving device, when addressed, is obliged to generate an acknowledge bit. A device that acknowledges must pull down the SDA line during the acknowledge clock pulse in such a way that the SDA line is stable low during the high period of the Acknowledge clock pulse. Setup and hold times must be taken into account. On a master receive, the termination of the data transfer can be signaled by the master generating a *not-acknowledge* (1) on the last byte that has been transmitted by the slave.

Bus Idle Both SDA and SCL lines remain high.

Data Transfer The number of data bytes transferred between a START and a STOP condition is not limited and is determined by the master device. The TMP102 device can also be used for single byte updates. To update only the MS byte, terminate the communication by issuing a START or STOP communication on the bus.

Start Data Transfer A change in the state of the SDA line, from high to low, when the SCL line is high, defines a START condition. Each data transfer is initiated with a START condition.

Stop Data Transfer A change in the state of the SDA line from low to high when the SCL line is high defines a STOP condition. Each data transfer is terminated with a repeated START or STOP condition.

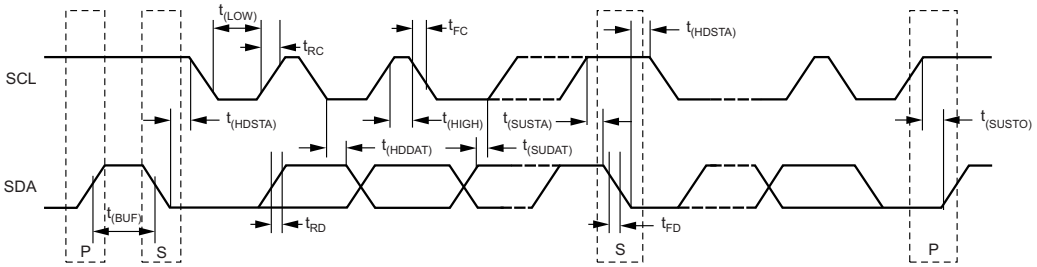
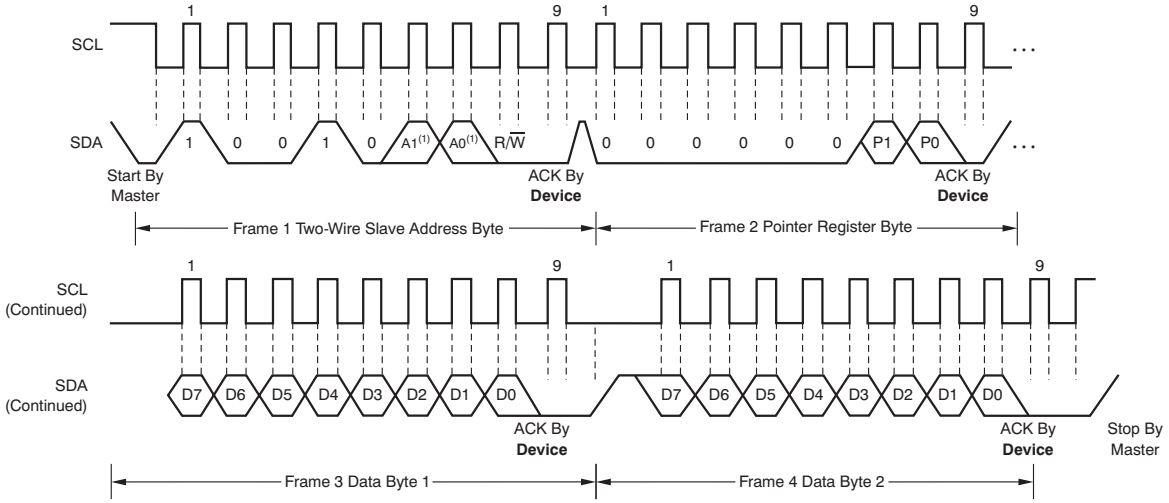
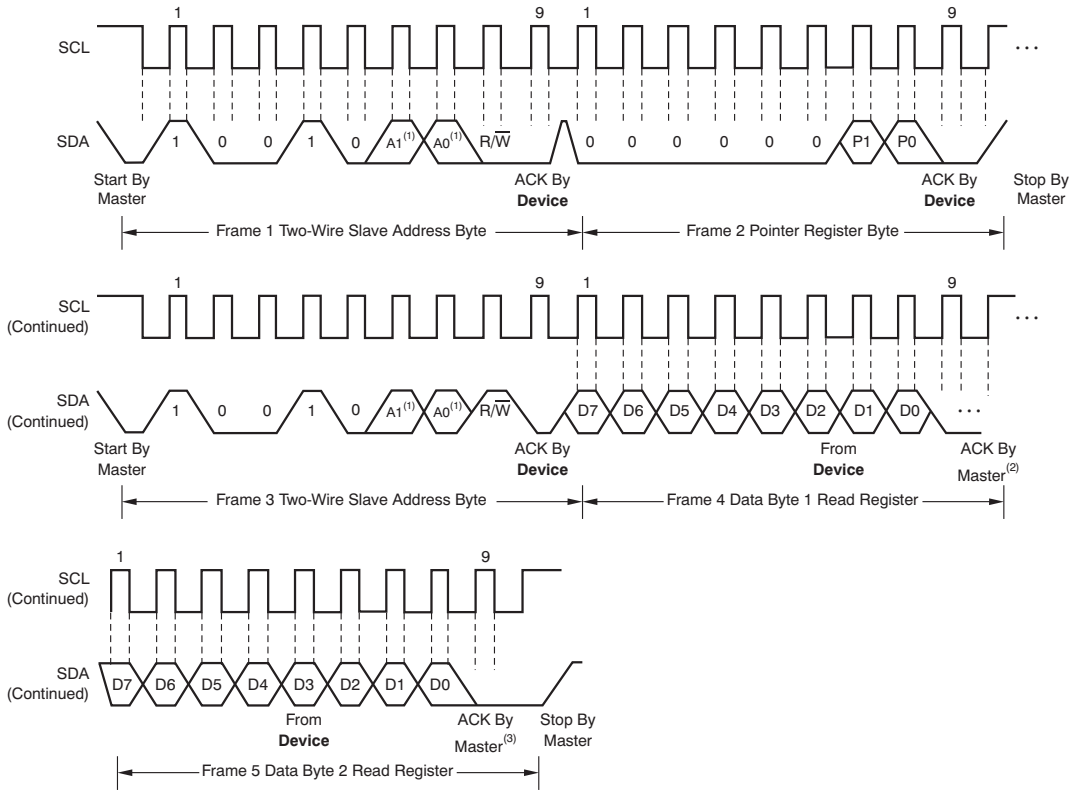


Figure 7. Two-Wire Timing Diagram



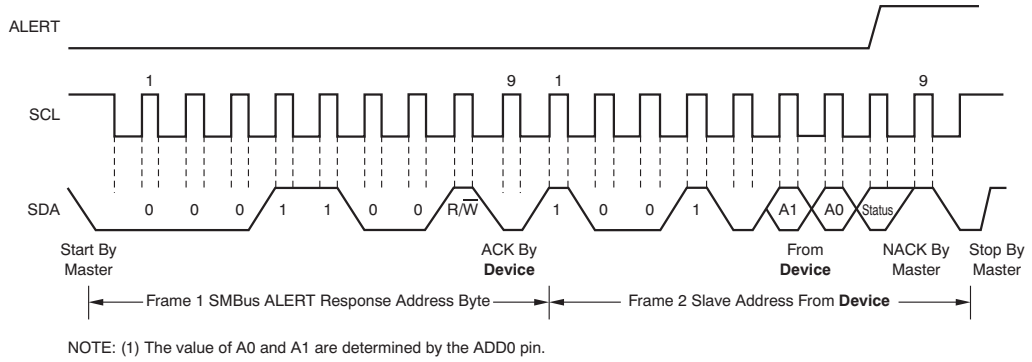
NOTE: (1) The value of A0 and A1 are determined by the ADD0 pin.

Figure 8. Two-Wire Timing Diagram for Write Word Format



NOTE: (1) The value of A0 and A1 are determined by the ADD0 pin.
(2) Master should leave SDA high to terminate a single-byte read operation.
(3) Master should leave SDA high to terminate a two-byte read operation.

Figure 9. Two-Wire Timing Diagram for Read Word Format



NOTE: (1) The value of A0 and A1 are determined by the ADD0 pin.

Figure 10. Timing Diagram for SMBus Alert

7.4 设备功能模式

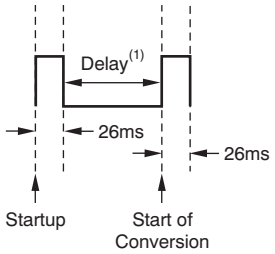
7.4.1 连续转换模式

TMP102 器件的默认模式是连续转换模式。 在连续转换模式下，ADC 执行连续温度转换并将每个结果存储到温度寄存器，覆盖前一次转换的结果。 转换率位 CR1 和 CR0 将 TMP102 器件配置为 0.25 Hz、1 Hz、4 Hz 或 8 Hz 的转换率。 默认速率为 4 Hz。 TMP102 器件的典型转换时间为 26 ms。 为了实现不同的转换率，TMP102 器件进行一次转换，然后断电以等待CR1 和CR0 设置的适当延迟。 表5 列出了CR1 和CR0 的设置。

Table 5. Conversion Rate Settings

CR1	CR0	CONVERSION RATE
0	0	0.25 Hz
0	1	1 Hz
1	0	4 Hz (default)
1	1	8 Hz

上电或通用调用复位后，TMP102 立即开始转换，如图 11 所示。第一个结果在 26 ms（典型值）后可用。 转换期间的有效静态电流为40 uA（典型值为+27°C ）。 延迟期间的静态电流为2.2 uA（典型值为+27°C ）。



(1) Delay is set by CR1 and CR0.

Figure 11. Conversion Start

7.4.2 扩展模式(EM)

扩展模式位将器件配置为正常模式操作（EM=0 ）或扩展模式操作（EM=1 ）。 在正常模式下，温度寄存器和上下限寄存器使用12 位数据格式。 正常模式用于使TMP102 器件与TMP75 器件兼容。
扩展模式 (EM = 1) 允许通过配置温度寄存器以及 13 位数据格式的上限和下限寄存器来测量 128° C 以上的温度。

7.4.3 关机模式 (SD)

关断模式位通过关断串行接口以外的所有器件电路来最大程度地节省功耗，将电流消耗降低到通常小于 0.5 uA。 当SD 位为1 时，关闭模式使能； 当电流转换完成时，器件关闭。 当SD 等于0 时，器件保持连续转换状态。

7.4.4 一次性/转换就绪 (OS)

TMP102 器件具有一次性温度测量模式。 当器件处于关断模式时，向 OS 位写入 1 将启动单次温度转换。 在转换过程中，OS 位读为“0”。 单次转换完成后，器件返回关断状态。 转换后，OS 位读取 1。当不需要连续温度监控时，此功能可降低TMP102 器件的功耗。

由于转换时间短，TMP102 器件实现了更高的转换率。 单次转换通常需要 26 毫秒，读取可以在不到 20 微秒内完成。 使用One-Shot 模式时，每秒可进行30 次或更多转换。

7.4.5 Thermostat Mode (TM)

恒温器模式位指示器件是在比较器模式（TM=0 ）还是中断模式（TM=1 ）下工作。

7.4.5.1 Comparator Mode (TM = 0)

在比较器模式 (TM = 0) 下，当温度等于或超过 T(HIGH) 寄存器中的值时，警报引脚被激活，并保持活动状态，直到温度低于T(LOW) 寄存器中的值。 有关比较器模式的更多信息，请参见上限和下限寄存器部分。

7.4.5.2 Interrupt Mode (TM = 1)

在中断模式 (TM = 1) 下，当温度超过 T(HIGH) 或低于 T(LOW) 寄存器时，警报引脚被激活。 当主机控制器读取温度寄存器时，警报引脚被清除。 有关中断模式的更多信息，请参见上限和下限寄存器部分。

7.5 编程

7.5.1 指针寄存器

图 12 说明了 TMP102 器件的内部寄存器结构。 器件的 8 位指针寄存器用于寻址给定的数据寄存器。 指针寄存器使用两个最低有效字节 (LSB)（见表 15 和表 16）来标识哪些数据寄存器必须响应读或写命令。 表 6 标识了指针寄存器字节的位。 在写命令期间，P2 到 P7 必须始终为“0”。 表 7 描述了 TMP102 器件中可用寄存器的指针地址。 P1 和P0 的上电复位值为00 。默认情况下，TMP102 器件在上电时读取温度。

Programming (continued)

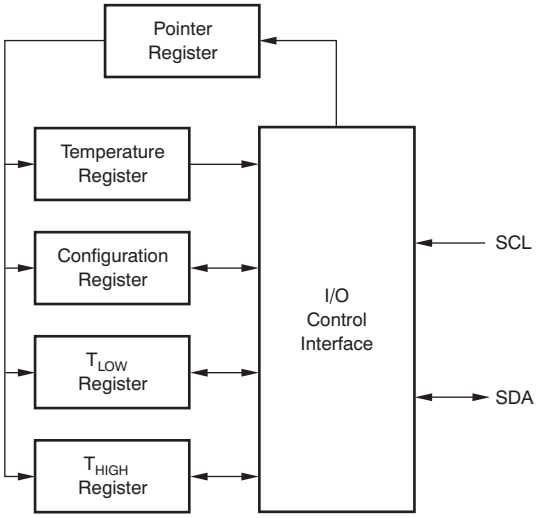


Figure 12. 内部寄存器结构

Table 6. 指针寄存器字节

P7	P6	P5	P4	P3	P2	P1	P0
0	0	0	0	0	0	寄存器位	

Table 7. Pointer Addresses

P1	P0	REGISTER
0	0	温度寄存器（只读）
0	1	配置寄存器（读/写）
1	0	TLOW 寄存器（读/写）
1	1	THIGH 寄存器（读/写）

7.5.2 温度寄存器

TMP102 的温度寄存器配置为 12 位只读寄存器（配置寄存器 EM 位 = 0，请参阅扩展模式部分）或 13 位只读寄存器（配置寄存器 EM 位 = 1) 存储最近转换的输出。 必须读取两个字节才能获得数据，如表 8 和表 9 所述。注意字节 1 是最高有效字节，其后是字节 2，最低有效字节。 前 12 位（扩展模式下为 13 位）用于指示温度。 如果不需要该信息，则不必读取最低有效字节。

Table 8. Byte 1 of Temperature Register(1)

D7	D6	D5	D4	D3	D2	D1	D0
T11	T10	T9	T8	T7	T6	T5	T4
(T12)	(T11)	(T10)	(T9)	(T8)	(T7)	(T6)	(T5)

(1) Extended mode 13-bit configuration shown in parenthesis.

Table 9. Byte 2 of Temperature Register(1)

D7	D6	D5	D4	D3	D2	D1	D0
T3	T2	T1	T0	0	0	0	0
(T4)	(T3)	(T2)	(T1)	(T0)	(0)	(0)	(1)

(1) Extended mode 13-bit configuration shown in parenthesis.

7.5.3 配置寄存器

配置寄存器是一个 16 位读/写寄存器，用于存储控制温度传感器工作模式的位。 读/写操作首先执行 MSB。 表 10 和表 11 列出了配置寄存器的格式和上电或复位值。 为了兼容性，表 10 和表 11 对应于 TMP75 器件和 TMP275 器件中的配置寄存器（有关更多信息，请分别参见器件数据表、SBOS288 和 SBOS363）。 所有寄存器都逐字节更新。

Table 10. 配置和上电或复位格式的字节1

D7	D6	D5	D4	D3	D2	D1	D0
OS	R1	R0	F1	F0	POL	TM	SD
0	1	1	0	0	0	0	0

Table 11. 配置和上电或复位格式的字节2

D7	D6	D5	D4	D3	D2	D1	D0
CR1	CR0	AL	EM	0	0	0	0
1	0	1	0	0	0	0	0

7.5.3.1 关机模式 (SD)

关断模式位通过关断串行接口以外的所有器件电路来最大程度地节省功耗，将电流消耗降低到通常小于 0.5 。 当 SD 位为1 时，关闭模式使能； 当电流转换完成时，器件关闭。 当SD 等于0 时，设备保持连续转换状态

7.5.3.2 恒温模式 (TM)

恒温器模式位指示器件是在比较器模式（TM = 0）还是中断模式（TM = 1）下工作。 有关比较器和中断模式的更多信息，请参见上限和下限寄存器部分。

7.5.3.3 极性 (POL)

极性位允许用户调整 ALERT 引脚输出的极性。 如果 POL 位设置为 0（默认），ALERT 引脚变为低电平有效。 当 POL 位设置为 1 时，ALERT 引脚变为高电平有效并且 ALERT 引脚的状态反转。 ALERT 引脚在各种模式下的操作如图13 所示。

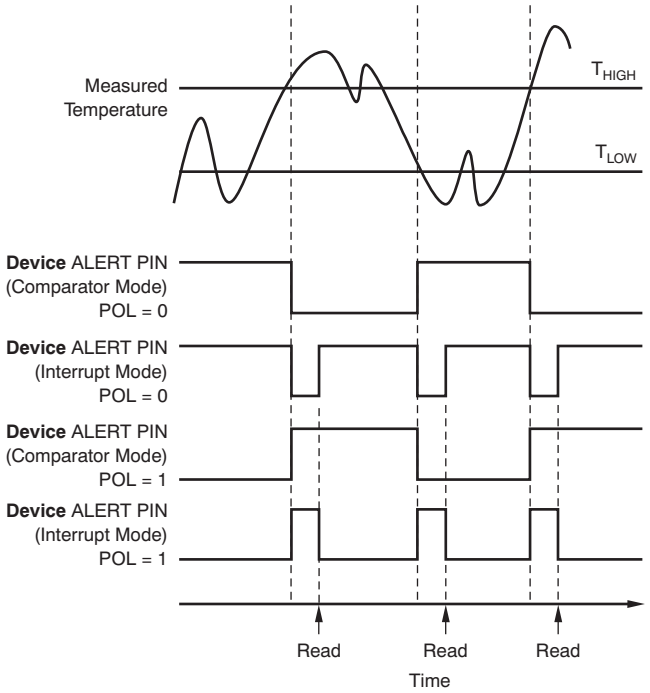


Figure 13. Output Transfer Function Diagrams

7.5.3.4 故障队列 (F1/F0)

当测得的温度超过在 THIGH 和 TLOW 寄存器中设置的用户定义限制时，就会出现故障条件。 此外，可以使用故障队列对生成警报所需的故障条件的数量进行编程。 提供故障队列是为了防止由于环境噪声引起的错误警报。 故障队列需要连续的故障测量才能触发警报功能。 表 12 定义了可通过编程触发设备警报条件的测量故障数量。 有关 THIGH 和TLOW 寄存器格式和字节顺序，请参见高限和低限寄存器部分。

Table 12. TMP102 Fault Settings

F1	F0	CONSECUTIVE FAULTS
0	0	1
0	1	2
1	0	4
1	1	6

7.5.3.5 转换器分辨率 (R1/R0)

转换器分辨率位R1 和R0 是只读位。TMP102 转换器分辨率在器件启动时设置为11 ，从而将温度寄存器设置为 12 位分辨率。

7.5.3.6 One-Shot (OS)

当器件处于关断模式时，向 OS 位写入 1 将启动单次温度转换。 在转换过程中，OS 位读为“0”。 单次转换完成后，器件返回关断状态。 有关一次性转换模式的更多信息，请参阅一次性/转换就绪(OS) 部分。

7.5.3.7 EM Bit

扩展模式位将器件配置为正常模式操作（EM = 0）或扩展模式操作（EM = 1）。 在正常模式下，温度寄存器、上限寄存器和下限寄存器使用12 位数据格式。 有关扩展模式的更多信息，请参阅扩展模式(EM) 部分。

7.5.3.8 Alert (AL Bit)

AL 位是只读功能。 读取 AL 位可提供有关比较器模式状态的信息。 POL 位的状态反转从 AL 位返回的数据的极性。 当 POL 位等于 0 时，AL 位读为 1，直到温度等于或超过编程的连续故障次数的 T(HIGH)，导致 AL 位读为 0。AL 位继续读为 0，直到 对于编程的连续故障次数，温度低于 T(LOW)，当它再次读取为 1 时。TM 位的状态不影响AL 位的状态。

7.5.3.9 Conversion Rate (CR)

转换率位CR1 和CR0 将TMP102 器件配置为0.25Hz 、1Hz 、4Hz 或8Hz 的转换率。 默认速率为4Hz 。 有关转换率位的更多信息，请参见表5 。

7.5.4 上限和下限寄存器

温度限制以与温度结果相同的格式存储在 T(LOW) 和 T(HIGH) 寄存器中，并且在每次转换时将它们的值与温度结果进行比较。比较的结果驱动 ALERT 引脚的行为，该引脚作为比较器输出或中断运行，并由配置寄存器中的 TM 位设置。

在比较器模式 (TM = 0) 下，当温度等于或超过 THIGH 中的值时，ALERT 引脚变为活动状态，并根据故障位 F1 和 F0 产生连续数量的故障。对于相同数量的故障，ALERT 引脚保持活动状态，直到温度低于指示的TLOW 值。

在中断模式 (TM = 1) 下，当温度在连续多个故障条件下等于或超过 THIGH 中的值时，ALERT 引脚变为活动状态（如表 5 所示）。 ALERT 引脚保持活动状态，直到发生任何寄存器的读操作，或者器件成功响应 SMBus 警报响应地址。如果器件处于关断模式，ALERT 引脚也将被清零。当 ALERT 引脚被清除时，只有当温度低于 TLOW 时它才会再次激活，并保持激活状态，直到被任何寄存器的读取操作或对 SMBus 警报响应地址的成功响应清除为止。当 ALERT 引脚被清除时，上述循环重复进行，当温度等于或超过 THIGH 时，ALERT 引脚变为活动状态。 ALERT 引脚也可以通过使用广播呼叫复位命令复位器件来清除。此操作还会清除器件内部寄存器的状态，使器件返回到比较器模式(TM=0) 。

图 13 中表示了两种操作模式。表 13 到表 16 描述了 THIGH 和 TLOW 寄存器的格式。请注意，首先发送最高有效字节，然后是最低有效字节。 THIGH 和 TLOW 的上电复位值为：THIGH = +80°C 和 TLOW = +75°C。 THIGH 和 TLOW 的数据格式与温度寄存器相同。

Table 13. Byte 1 Temperature Register $_{HIGH}$ (1)

D7	D6	D5	D4	D3	D2	D1	D0
H11	H10	H9	H8	H7	H6	H5	H4
(H12)	(H11)	(H10)	(H9)	(H8)	(H7)	(H6)	(H5)

(1) Extended mode 13-bit configuration shown in parenthesis.

Table 14. Byte 2 Temperature Register $_{HIGH}$

D7	D6	D5	D4	D3	D2	D1	D0
H3	H2	H1	H0	0	0	0	0
(H4)	(H3)	(H2)	(H1)	(H0)	(0)	(0)	(0)

Table 15. Byte 1 Temperature Register $_{LOW}$ (1)

D7	D6	D5	D4	D3	D2	D1	D0
L11	L10	L9	L8	L7	L6	L5	L4
(L12)	(L11)	(L10)	(L9)	(L8)	(L7)	(L6)	(L5)

(1) Extended mode 13-bit configuration shown in parenthesis.

Table 16. Byte 2 Temperature Register $_{LOW}$

D7	D6	D5	D4	D3	D2	D1	D0
L3	L2	L1	L0	0	0	0	0
(L4)	(L3)	(L2)	(L1)	(L0)	(0)	(0)	(0)

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The TMP102 device is used to measure the PCB temperature of the board location where the device is mounted. The programmable address options allow up to four locations on the board to be monitored on a single serial bus.

8.2 Typical Application

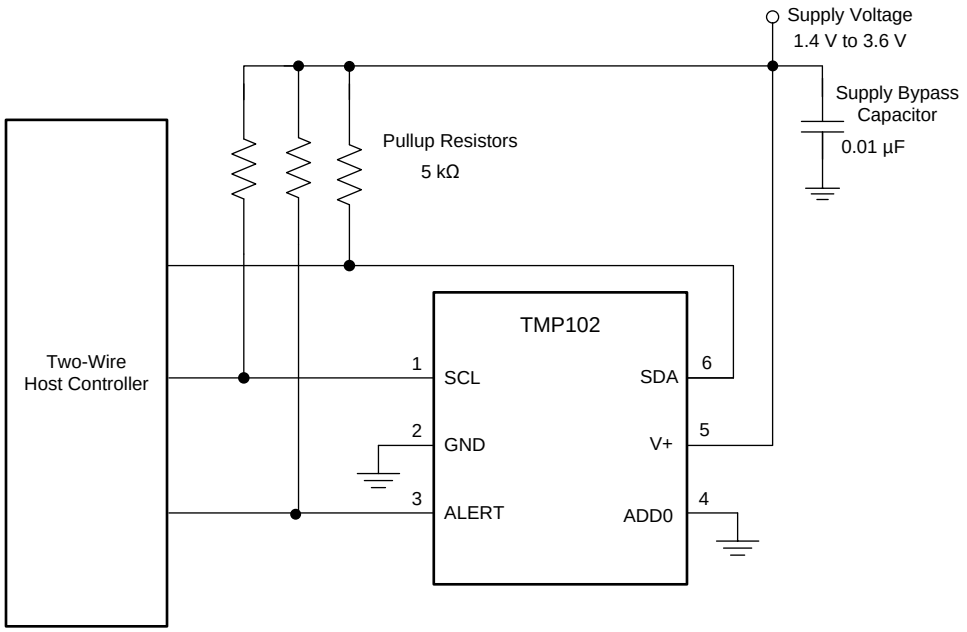


Figure 14. Typical Connections

8.2.1 Design Requirements

The TMP102 device requires pullup resistors on the SCL, SDA, and ALERT pins. The recommended value for the pullup resistors is 5-kΩ. In some applications the pullup resistor can be lower or higher than 5 kΩ but must not exceed 3 mA of current on any of those pins. A 0.01-µF bypass capacitor on the supply is recommended as shown in Figure 14. The SCL and SDA lines can be pulled up to a supply that is equal to or higher than V+ through the pullup resistors. To configure one of four different addresses on the bus, connect the ADD0 pin to either the GND, V+, SDA, or SCL pin.

8.2.2 Detailed Design Procedure

Place the TMP102 device in close proximity to the heat source that must be monitored, with a proper layout for good thermal coupling. This placement ensures that temperature changes are captured within the shortest possible time interval. To maintain accuracy in applications that require air or surface temperature measurement, care must be taken to isolate the package and leads from ambient air temperature. A thermally-conductive adhesive is helpful in achieving accurate surface temperature measurement.

Typical Application (continued)

The TMP102 device is a very low-power device and generates very low noise on the supply bus. Applying an RC filter to the V+ pin of the TMP102 device can further reduce any noise that the TMP102 device might propagate to other components. $R_{(F)}$ in Figure 15 must be less than 5 kΩ and $C_{(F)}$ must be greater than 10 nF.

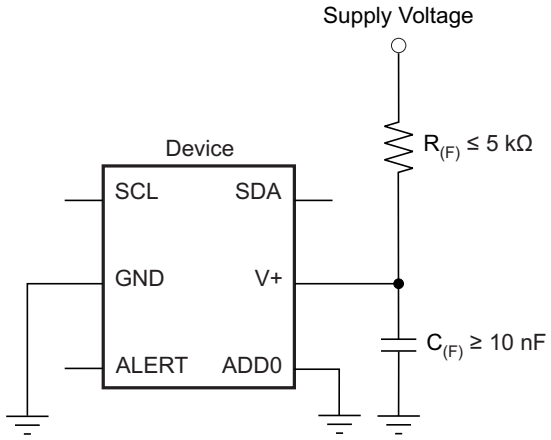


Figure 15. Noise Reduction Techniques

8.2.3 Application Curve

Figure 16 shows the step response of the TMP102 device to a submersion in an oil bath of 100ºC from room temperature (27ºC). The time-constant, or the time for the output to reach 63% of the input step, is 0.8 s. The time-constant result depends on the printed circuit board (PCB) that the TMP102 device is mounted. For this test, the TMP102 device was soldered to a two-layer PCB that measured 0.375 inch × 0.437 inch.

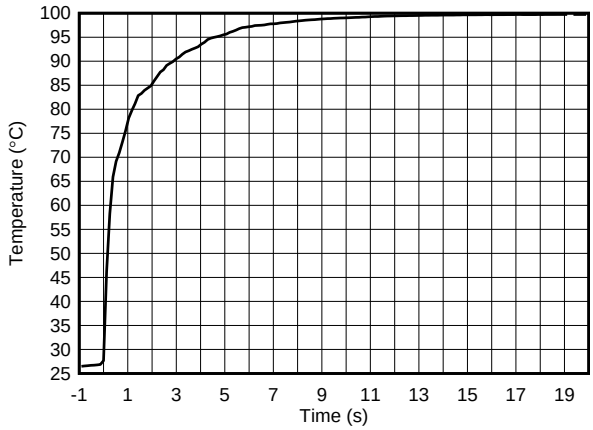


Figure 16. Temperature Step Response

9 Power Supply Recommendations

The TMP102 device operates with power supply in the range of 1.4 to 3.6 V. The device is optimized for operation at 3.3-V supply but can measure temperature accurately in the full supply range.

A power-supply bypass capacitor is required for proper operation. Place this capacitor as close as possible to the supply and ground pins of the device. A typical value for this supply bypass capacitor is 0.01 μF. Applications with noisy or high-impedance power supplies may require additional decoupling capacitors to reject power-supply noise.

10 Layout

10.1 Layout Guidelines

Place the power-supply bypass capacitor as close as possible to the supply and ground pins. The recommended value of this bypass capacitor is 0.01 μF. Additional decoupling capacitance can be added to compensate for noisy or high-impedance power supplies. Pull up the open-drain output pins (SDA , SCL and ALERT) through 5-kΩ pullup resistors.

10.2 Layout Example

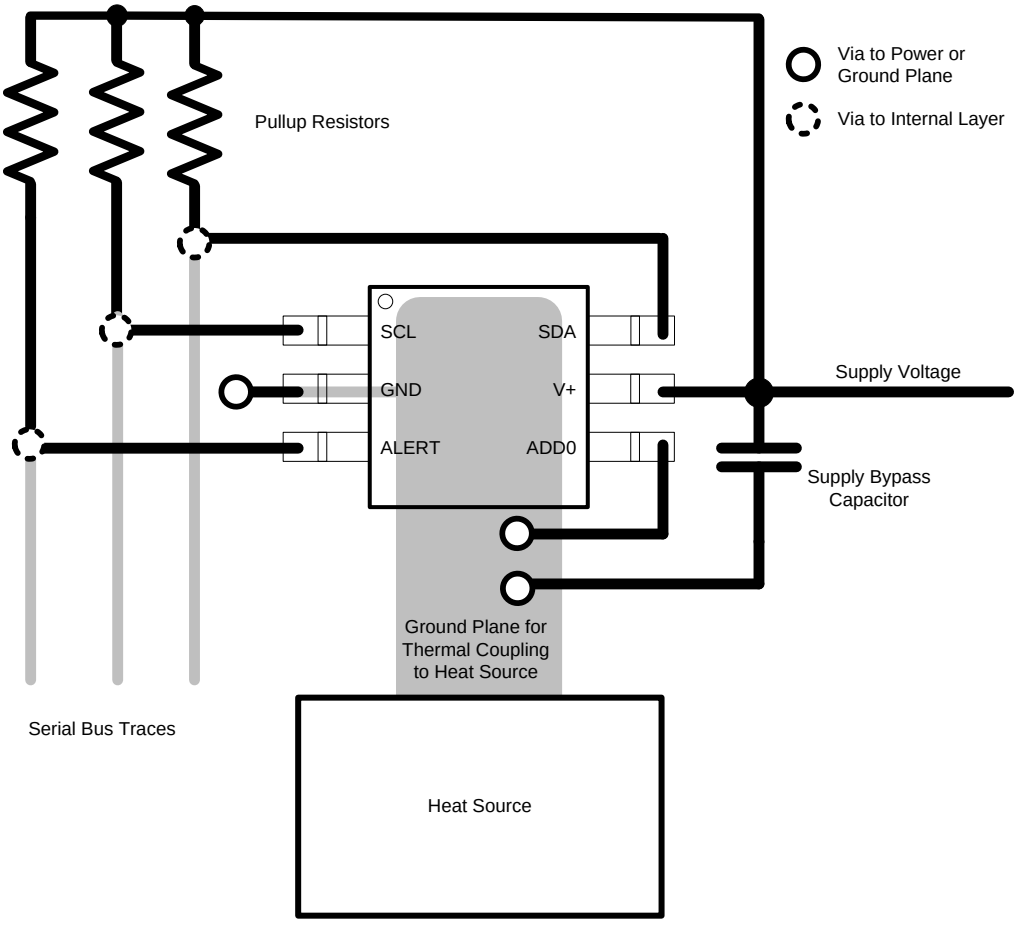


Figure 17. TMP102 Layout Example

11 器件和文档支持

11.1 文档支持

11.1.1 相关文档

请参阅如下相关文档：

- TMP175、TMP75 产品说明书，SBOS288
- TMP275 产品说明书，SBOS363
- *具有触觉反馈的电容触控式汽车 LED 座舱顶灯*设计指南

11.2 接收文档更新通知

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11.5 静电放电警告

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11.6 术语表

SLYZ022 — *TI 术语表*。

这份术语表列出并解释术语、缩写和定义。

12 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。如需获取此数据表的浏览器版本，请查阅左侧的导航栏。

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TMP102AIDRLR	ACTIVE	SOT-5X3	DRL	6	4000	RoHS & Green	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	CBZ	Samples
TMP102AIDRLRG4	ACTIVE	SOT-5X3	DRL	6	4000	RoHS & Green	NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	CBZ	Samples
TMP102AIDRLT	ACTIVE	SOT-5X3	DRL	6	250	RoHS & Green	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	CBZ	Samples
TMP102AIDRLTG4	ACTIVE	SOT-5X3	DRL	6	250	RoHS & Green	NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	CBZ	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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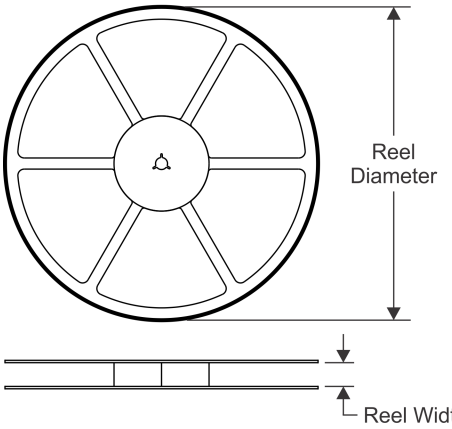
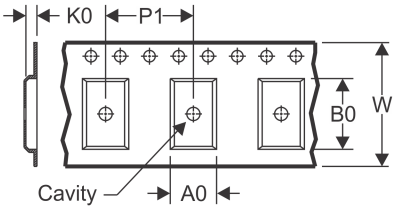
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

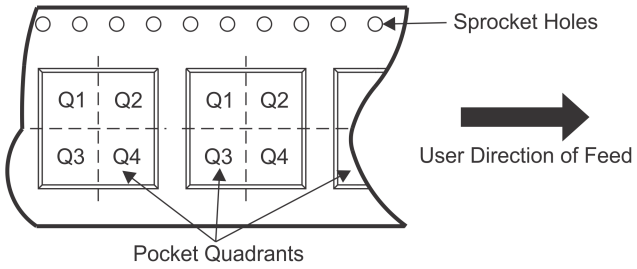


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

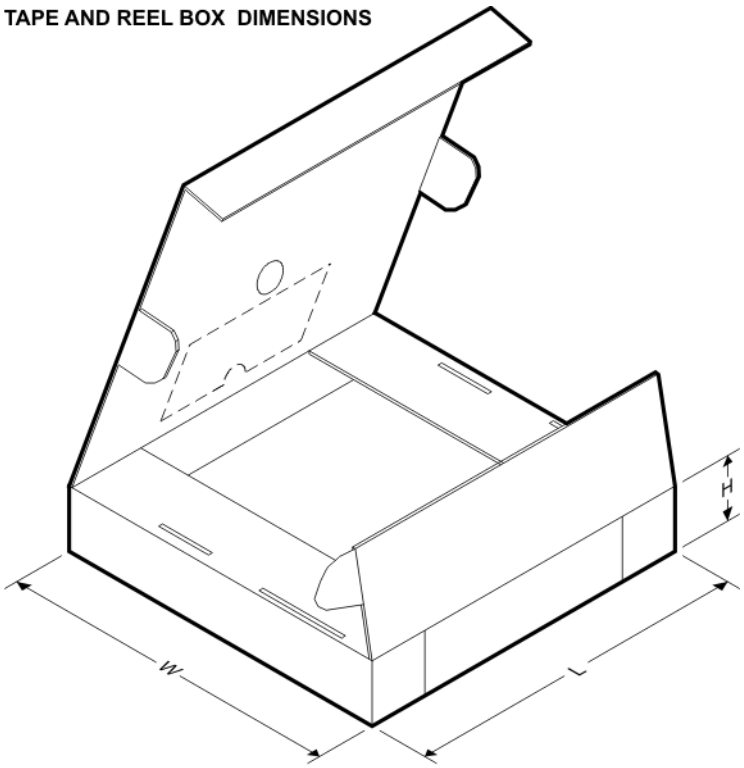
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TMP102AIDRLR	SOT-5X3	DRL	6	4000	180.0	9.5	1.78	1.78	0.69	4.0	8.0	Q3
TMP102AIDRLR	SOT-5X3	DRL	6	4000	180.0	8.4	1.98	1.78	0.69	4.0	8.0	Q3
TMP102AIDRLT	SOT-5X3	DRL	6	250	180.0	9.5	1.78	1.78	0.69	4.0	8.0	Q3
TMP102AIDRLT	SOT-5X3	DRL	6	250	180.0	8.4	1.98	1.78	0.69	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

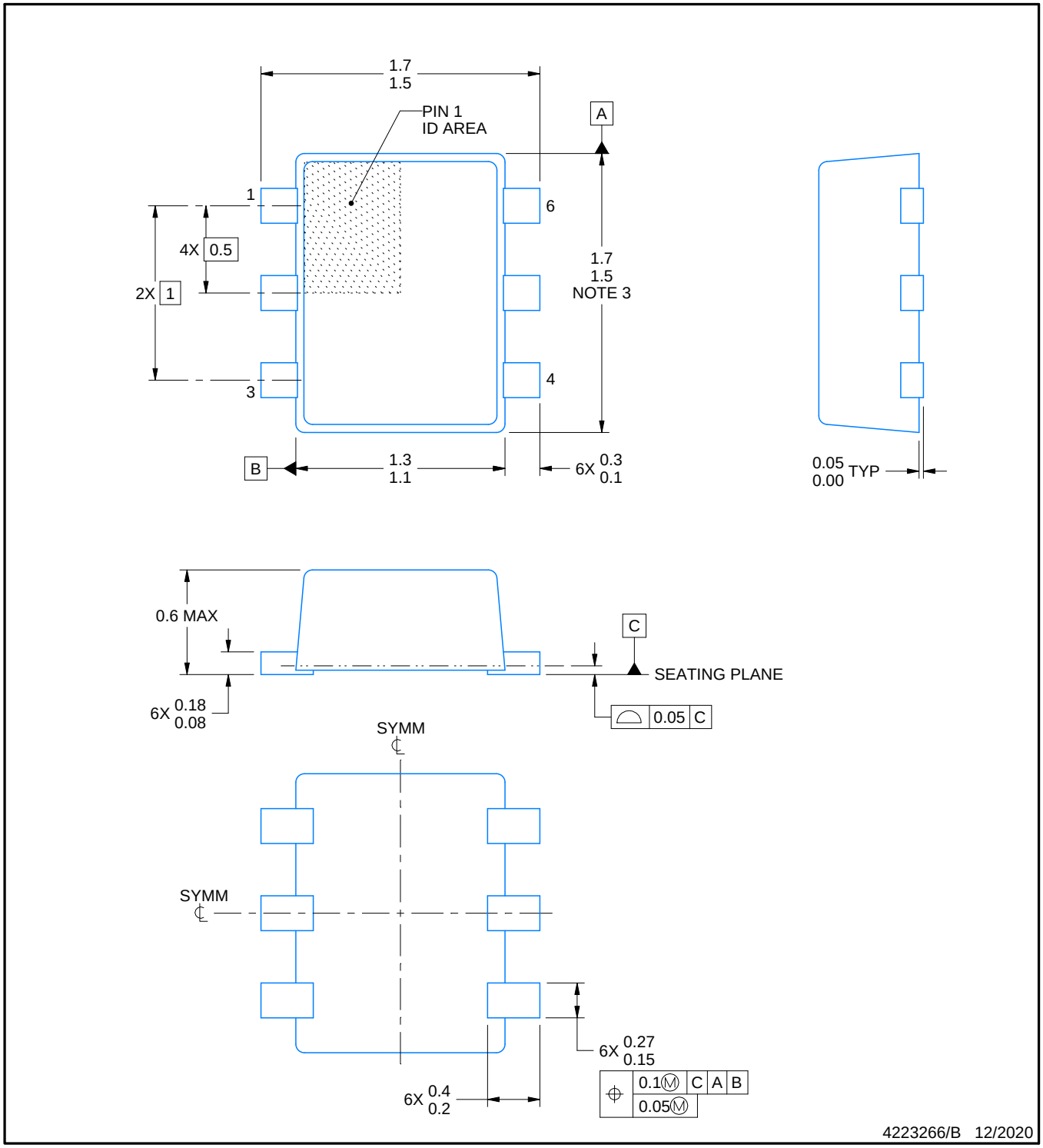
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMP102AIDRLR	SOT-5X3	DRL	6	4000	184.0	184.0	19.0
TMP102AIDRLR	SOT-5X3	DRL	6	4000	202.0	201.0	28.0
TMP102AIDRLT	SOT-5X3	DRL	6	250	184.0	184.0	19.0
TMP102AIDRLT	SOT-5X3	DRL	6	250	202.0	201.0	28.0

PACKAGE OUTLINE

DRL0006A

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



NOTES:

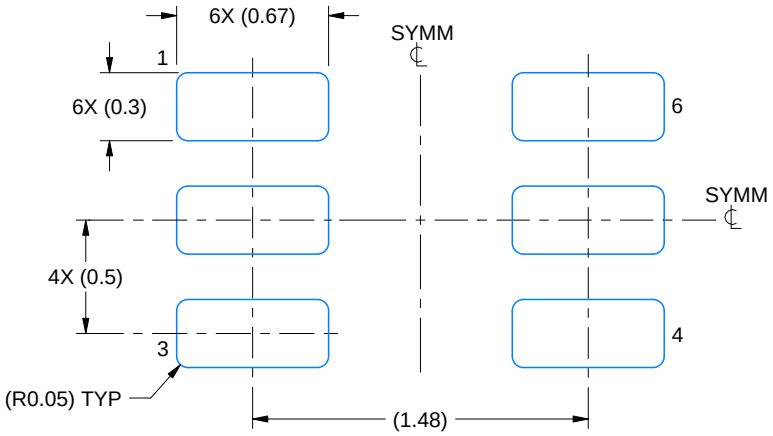
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-293 Variation UAAD

EXAMPLE BOARD LAYOUT

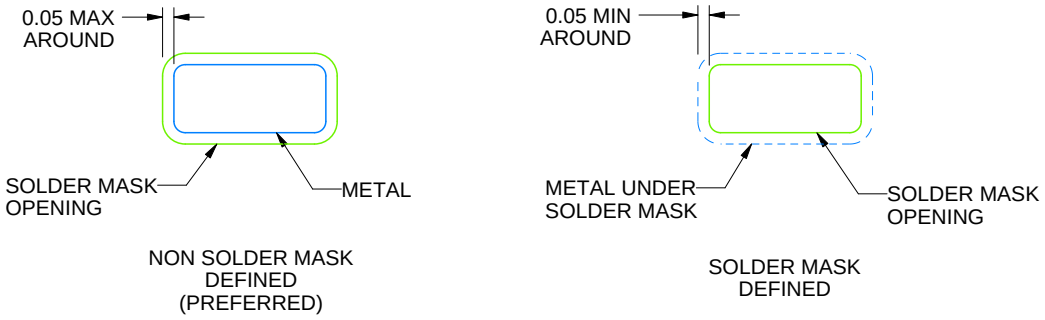
DRL0006A

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE
SCALE:30X

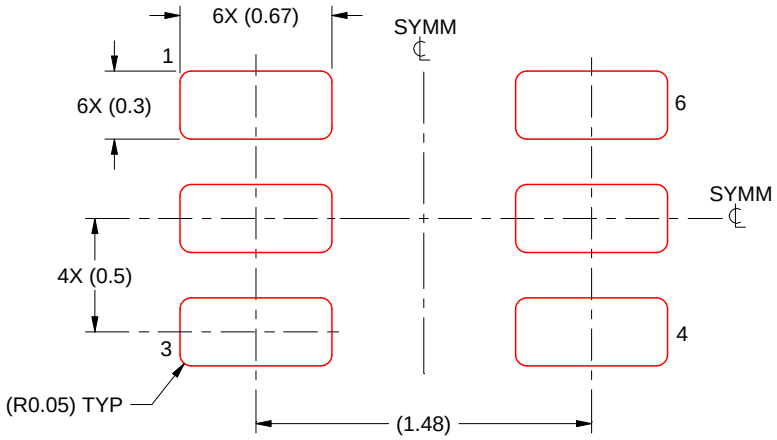


SOLDERMASK DETAILS

4223266/B 12/2020

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:30X

4223266/B 12/2020

NOTES: (continued)

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

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