2°C Accurate Digital Temperature Sensor with SPI™ Interface

FEATURES

- **DIGITAL OUTPUT: SPI-Compatible Interface**
- **RESOLUTION: 10-Bit, 0.25°C**
- **ACCURACY:**
  ±2.0°C (max) from −25°C to +85°C
  ±2.5°C (max) from −40°C to +125°C
- **LOW QUIESCENT CURRENT: 50μA (max)**
- **WIDE SUPPLY RANGE: 2.7V to 5.5V**
- **TINY SOT23-6 PACKAGE**
- **OPERATION FROM −40°C to +125°C**

APPLICATIONS

- **BASE STATION EQUIPMENT**
- **COMPUTER PERIPHERAL THERMAL PROTECTION**
- **NOTEBOOK COMPUTERS**
- **DATA ACQUISITION SYSTEMS**
- **TELECOM EQUIPMENT**
- **OFFICE MACHINES**

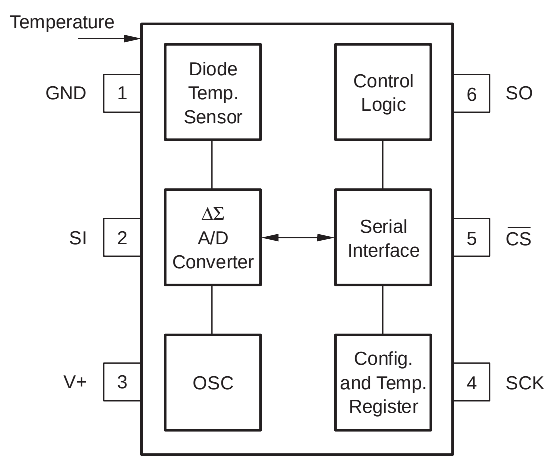
TMP125 RELATED PRODUCTS

FEATURES	PRODUCT
2°C Digital Temp Sensors with Two-Wire Interface	TMP100/101
1.5°C Digital Temp Sensors with Two-Wire Interface	TMP75/175
1.5°C Digital Temp Sensors with SPI	TMP121/123
1.5°C Programmable Digital Temp Sensors with SPI	TMP122/124

DESCRIPTION

The TMP125 is an SPI-compatible temperature sensor available in the tiny SOT23-6 package. Requiring no external components, the TMP125 is capable of measuring temperatures within 2°C of accuracy over a temperature range of −25°C to +85°C and 2.5°C of accuracy over −40°C to +125°C. Low supply current, and a supply range from 2.7V to 5.5V, make the TMP125 an excellent candidate for low-power applications.

The TMP125 is ideal for extended thermal measurement in a variety of communication, computer, consumer, environmental, industrial, and instrumentation applications.



TMP125

ABSOLUTE MAXIMUM RATINGS(1)

Supply Voltage	+7V
Input Voltage(2)	−0.3V to +7V
Input Current	±10mA
Output Short Circuit(3)	Continuous
Operating Temperature Range	−55°C to +125°C
Storage Temperature Range	−60°C to +150°C
Junction Temperature (T_J max)	+150°C
Lead Temperature (soldering)	+300°C
ESD Rating (Human Body Model)	4000V
(Charged Device Model)	1000V

(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 terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current limited to 10mA or less.

(3) Short-circuit to ground.

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

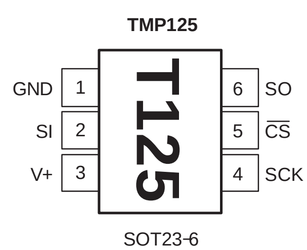
ORDERING INFORMATION(1)

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	PACKAGE MARKING
TMP125	SOT23-6	DBV	T125

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

PIN CONFIGURATION

Top View



NOTE: Pin 1 is determined by orienting the package marking as shown.

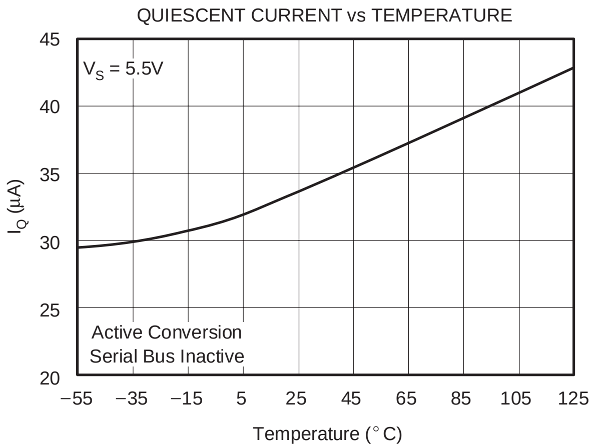
ELECTRICAL CHARACTERISTICS

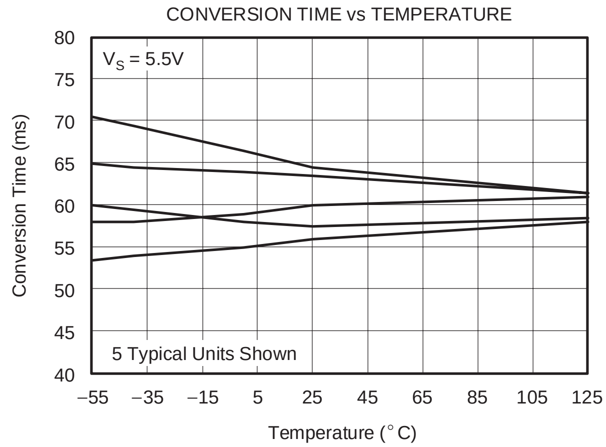
At T_A = −40°C to +125°C and V_S = +2.7V to 5.5V, unless otherwise noted.

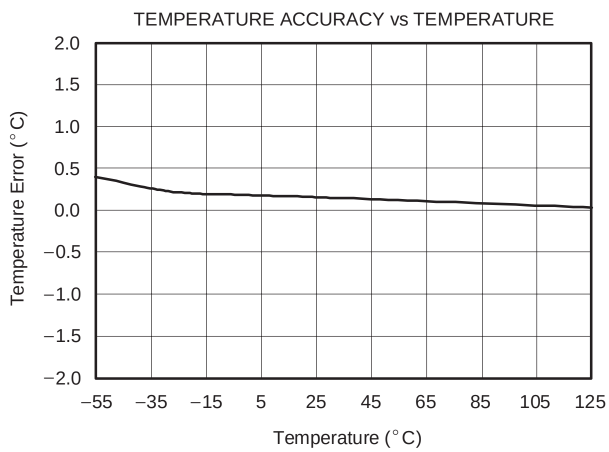
PARAMETER		CONDITIONS	TMP125 MIN	TMP125 TYP	TMP125 MAX	UNIT
TEMPERATURE INPUT						
Range			−40		+125	°C
Accuracy (temperature error)		−25°C to +85°C		±0.5	±2.0	°C
		−40°C to +125°C		±1.0	±2.5	°C
Resolution				10		Bits
Temperature Measurement Noise				0.1		LSB
DIGITAL INPUT/OUTPUT						
Input Logic Levels:						
V_{IH}			0.7(V+)			V
V_{IL}					0.3(V+)	V
Input Current, SI, SCK, $\overline{CS}$	I_{IN}	0V = V_{IN} = V+			±1	µA
Output Logic Levels:						
V_{OL} SO		I_{SINK} = 3mA			0.4	V
V_{OH} SO		I_{SOURCE} = 2mA	(V+)−0.4			V
Input Capacitance, SI, SCK, $\overline{CS}$				2.5		pF
Conversion Time		10-Bit		60		ms
Update Rate				120		ms
POWER SUPPLY						
Operating Range			2.7		5.5	V
Quiescent Current, at T_A = 25°C	I_Q	Serial Bus Inactive		36	50	µA
over Temperature		−40°C to +125°C			60	µA
Shutdown Current				0.1	1	µA
over Temperature					1	µA
TEMPERATURE RANGE						
Specified Range			−40		+125	°C
Operating Range			−55		+125	°C
Storage Range			−60		+150	°C
Thermal Resistance	θ_{JA}	SOT23-6 Surface-Mount		200		°C/W

TYPICAL CHARACTERISTICS

At T_A = −40°C to +125°C and V_S = +2.7V to 5.5V, unless otherwise noted.







APPLICATIONS

The TMP125 10-bit, read-only digital temperature sensor is optimal for thermal management and thermal protection applications. The TMP125 is specified for a temperature range of −40°C to +125°C, with operation extending down to −55°C. It is specified for a supply voltage range of 2.7V to 5.5V, and also features a hardware shutdown to provide power savings. Quiescent current is reduced to 1µA during analog shutdown.

The TMP125 communicates through a serial interface that is SPI-compatible. Temperature is converted to a 10-bit data word with 0.25°C resolution. The TMP125 is optimal for low-power applications, with a 120ms conversion period for reduced power consumption.

The sensing device of the TMP125 is the chip itself. Thermal paths run through the package leads as well as the plastic package, and the lower thermal resistance of metal causes the leads to provide the primary thermal path.

The TMP125 requires no external components for operation, though a 0.1µF supply bypass capacitor is recommended. Figure 1 shows typical connection for the TMP125.

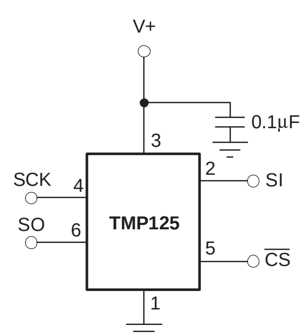


Figure 1. Typical Connections for the TMP125

COMMUNICATING WITH THE TMP125

The TMP125 continuously converts temperatures to digital data. Temperature data is read by pulling $\overline{CS}$ low. Once $\overline{CS}$ is pulled low, temperature data from the last completed conversion prior to dropping $\overline{CS}$ is latched into the shift register and clocked out at SO on the falling SCK edge. The 16-bit data word is clocked out sign bit first, followed by the MSB. The SI pin is used to put the device into shutdown mode. To enter shutdown mode, SI must be high on the rising edge of the third bit of SCK (see Figure 3). Also, all 16 bits must be clocked to allow shutdown on the TMP125. To bring the device out of shutdown, perform a 16-clock communication with SI set to logic low. The 16-clock communication is the same as the Data Read shown in Figure 3, except that the data on SO will be the last conversion prior to putting the device into shutdown mode. Note that SO is only used to control the shutdown function; if not using this function, connect this pin to ground.

The one-shot command can be used to force a single conversion. When the command is issued, the part will perform a single conversion and then go into shutdown mode. After the conversion is complete, the conversion result should be read with the power-down bit high (see Figure 3) if you do not want to start a new conversion.

The TMP125 will go into idle mode for 60ms, requiring only 20µA of current. A new conversion begins every 120ms. Figure 2 describes the conversion timing for the TMP125.

TEMPERATURE REGISTER

The Temperature Register of the TMP125 is a 16-bit, read-only register that stores the output of the most recent conversion. However, temperature is represented by only 10-bits, which are in signed two's complement format. The first bit of the Temperature Register, D15, is a leading zero. Bits D14 and D5 are used to indicate temperature. Bits D4 to D0 are the same as D5 (see Table 1). Data format for temperature is summarized in Table 2. When calculating the signed two's complement temperature value, be sure to use only the 10 data bits.

Following power-up or reset, the Temperature Register will read 0°C until the first conversion is complete.

D15	D14	D13	D12	D11	D10	D9	D8
0	T9	T8	T7	T6	T5	T4	T3

D7	D6	D5	D4	D3	D2	D1	D0
T2	T1	T0	T0	T0	T0	T0	T0

Table 1. Temperature Register

TEMPERATURE (°C)	DIGITAL OUTPUT D14…D5
+127	01 1111 1100
+125	01 1111 0100
+100	01 1001 0000
+75	01 0010 1100
+50	00 1100 1000
+25	00 0110 0100
+10	00 0010 1000
+0.25	00 0000 0001
0	00 0000 0000
−0.25	11 1111 1111
−25	11 1001 1100
−50	11 0011 1000
−55	11 0010 0100

Table 2. Temperature Data Format

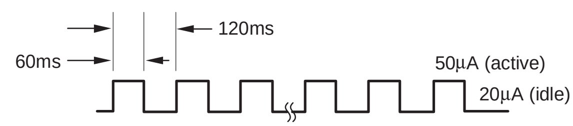


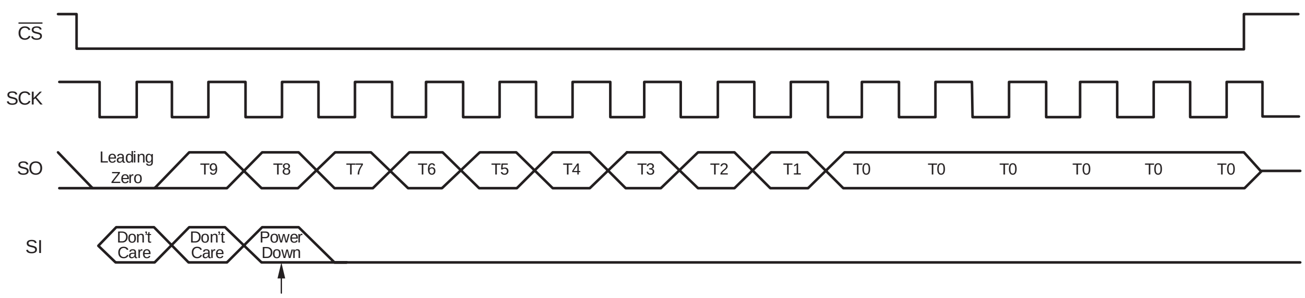
Figure 2. Conversion Time and Period

Timing Diagrams

The TMP125 is SPI-compatible. Figure 3 and Figure 4 describe the output data of the TMP125. Figure 5, Figure 6, and Figure 7 describe the various timing requirements, with parameters defined in Table 3.

PARAMETER		MIN	MAX	UNITS
SCK Period	t_1	100		ns
Data In to Rising Edge SCK Setup Time	t_2	20		ns
SCK Falling Edge to Output Data Delay	t_3		30	ns
SCK Rising Edge to Input Data Hold Time	t_4	20		ns
$\overline{CS}$ to Rising Edge SCK Set-Up Time	t_5	40		ns
$\overline{CS}$ to Output Data Delay	t_6		30	ns
$\overline{CS}$ Rising Edge to Output High Impedance	t_7		30	ns

Table 3. Timing Description



To enter shutdown mode, SI must be high on the rising edge of the third bit of SCK (see the *Communicating with the TMP125* section).

Figure 3. Data READ

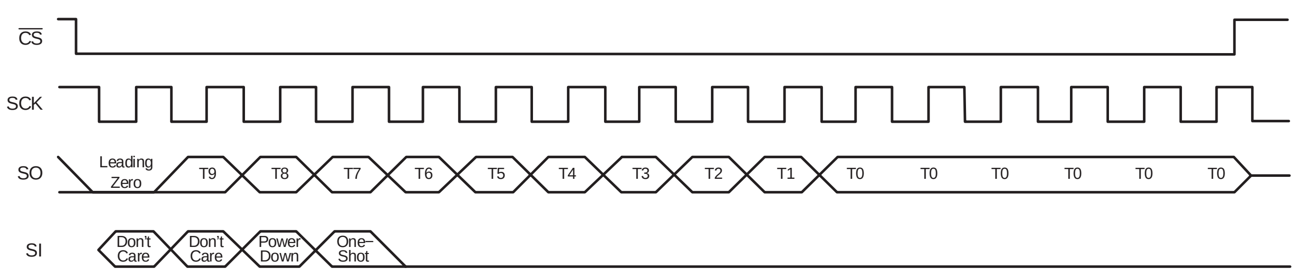


Figure 4. One-Shot Command

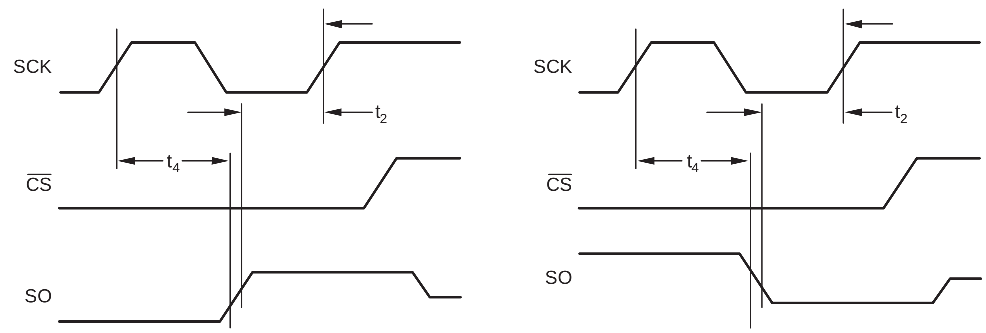


Figure 5. Input Data Timing Diagram

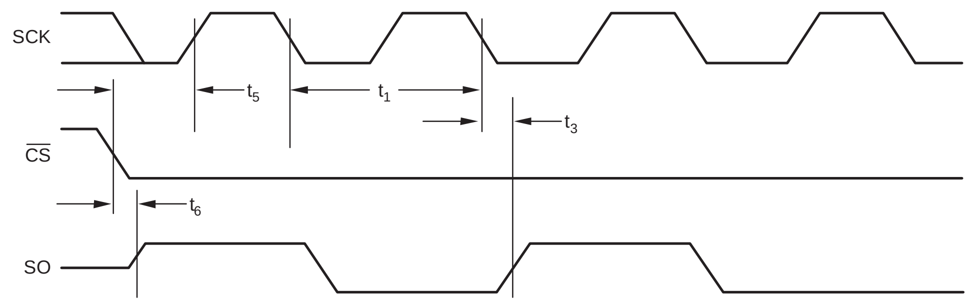


Figure 6. Output Data Timing Diagram

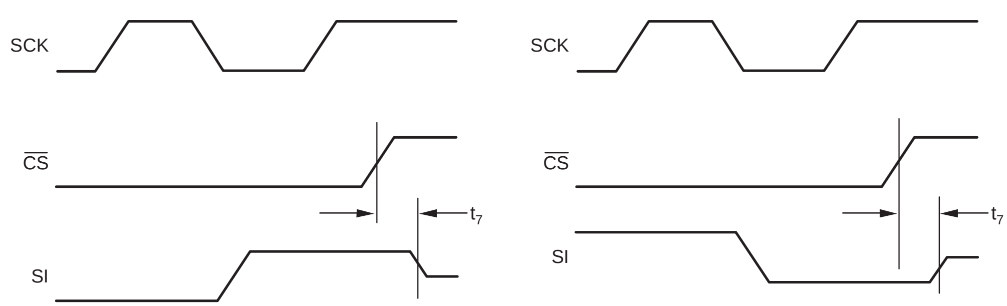


Figure 7. High Impedance Output Timing Diagram

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
HPA00444AIDBVT	ACTIVE	SOT-23	DBV	6	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T125	Samples
TMP125AIDBVR	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T125	Samples
TMP125AIDBVRG4	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T125	Samples
TMP125AIDBVT	ACTIVE	SOT-23	DBV	6	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T125	Samples
TMP125AIDBVTG4	ACTIVE	SOT-23	DBV	6	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T125	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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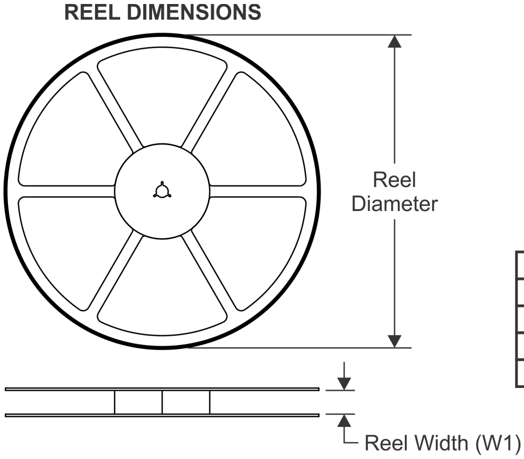
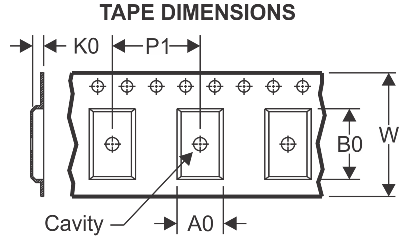
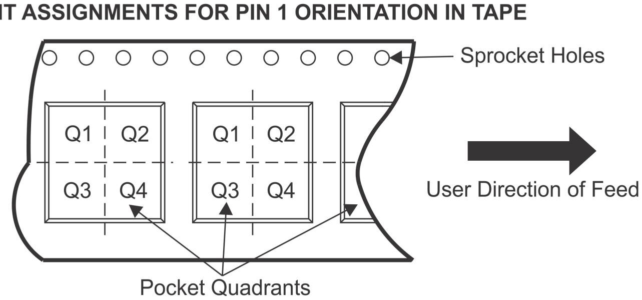
TAPE AND REEL INFORMATION





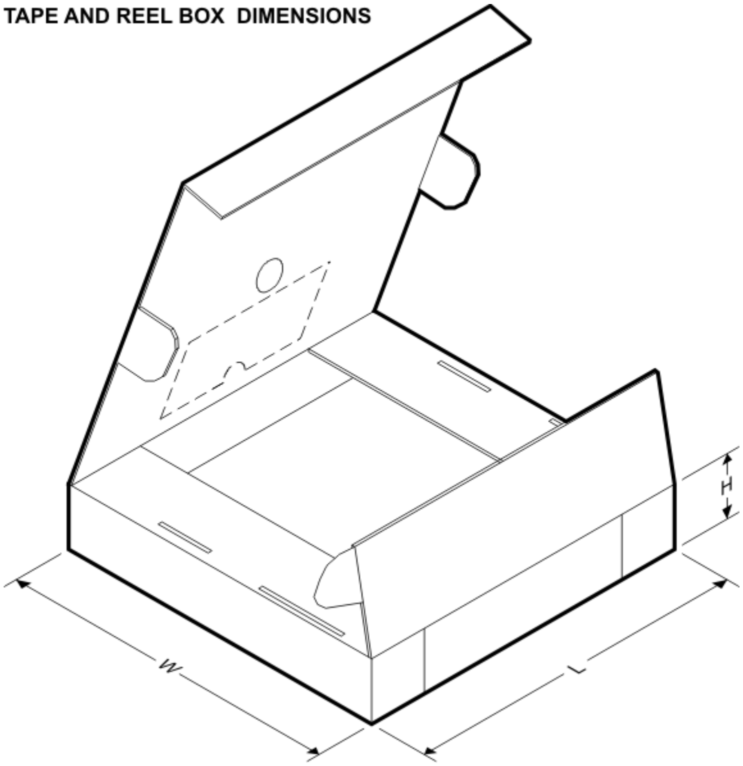
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*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
TMP125AIDBVR	SOT-23	DBV	6	3000	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
TMP125AIDBVT	SOT-23	DBV	6	250	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



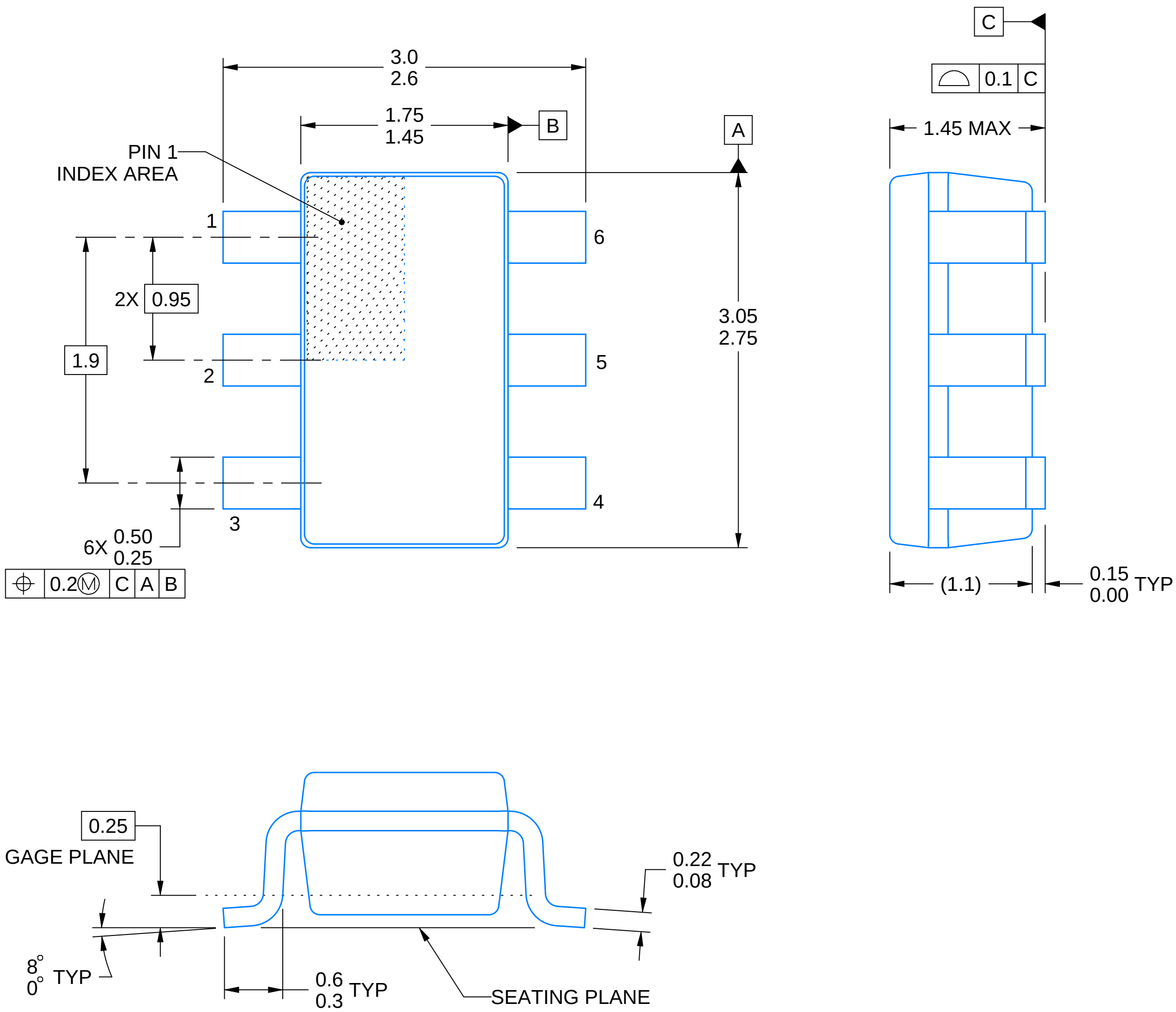
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMP125AIDBVR	SOT-23	DBV	6	3000	445.0	220.0	345.0
TMP125AIDBVT	SOT-23	DBV	6	250	445.0	220.0	345.0

PACKAGE OUTLINE

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



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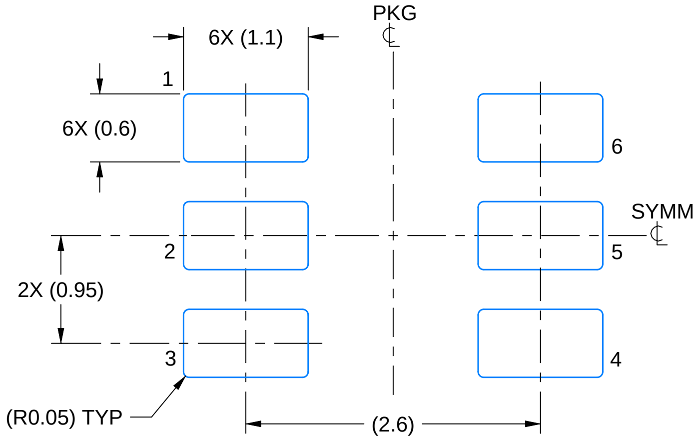
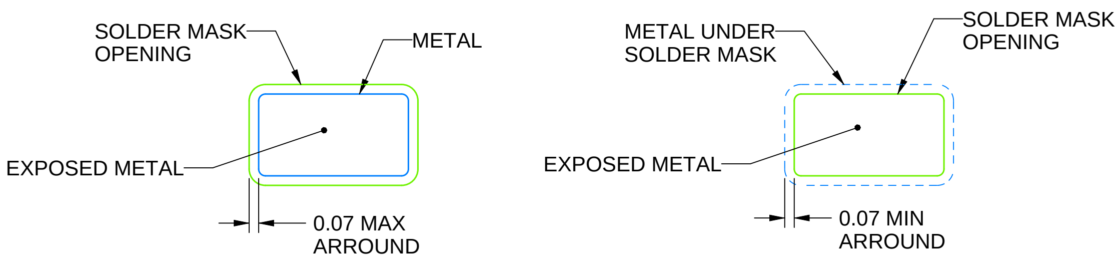
NOTES:

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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Refernce JEDEC MO-178.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

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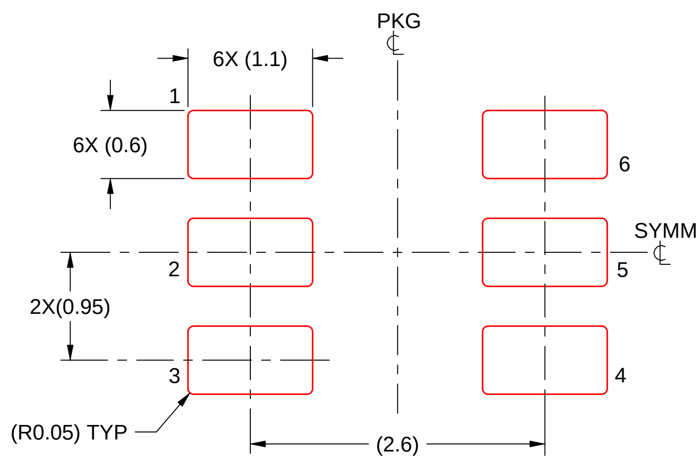
NOTES: (continued)

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



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

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NOTES: (continued)

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

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