SBOS323 − DECEMBER 2004

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**

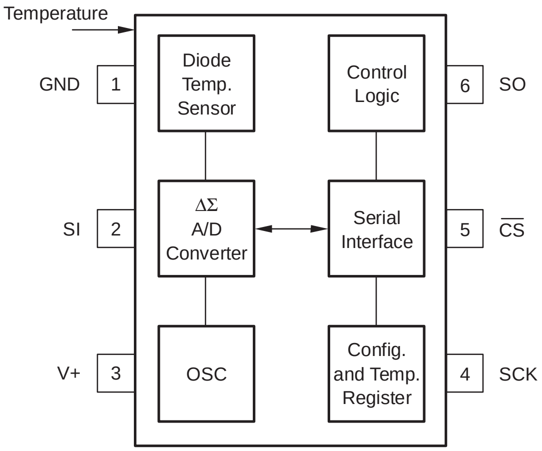
TMP125 RELATED PRODUCTS

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

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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.

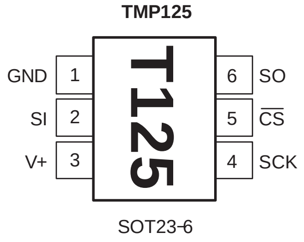
ORDERING INFORMATION(1)

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 located at the end of this data sheet.

PIN CONFIGURATION

Top View



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

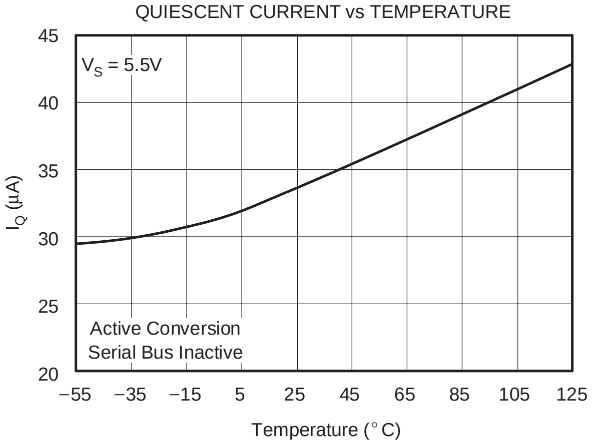
ELECTRICAL CHARACTERISTICS

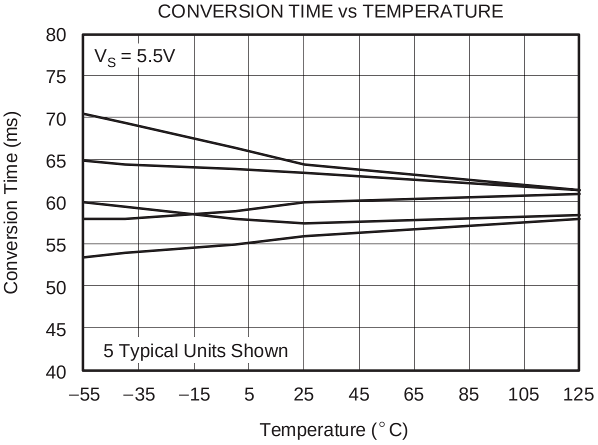
At T_A = −40°C to +125°C and V_S = +2.7V to 5.5V, unless otherwise noted.

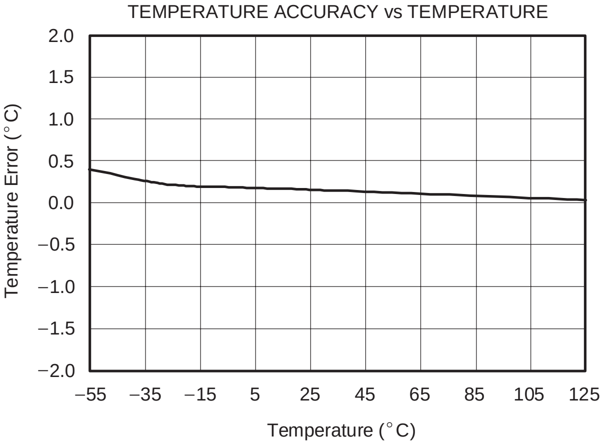
		TMP125			
PARAMETER	**CONDITIONS**	**MIN**	**TYP**	**MAX**	**UNIT**
TEMPERATURE INPUT					
Range		−40		+125	°C
Accuracy (temperature error)	−25°C to +85°C		±0.5	±2.0	°C
	−40°C to +125°C		±1.0	±2.5	°C
Resolution			10		Bits
Temperature Measurement Noise			0.1		LSB
DIGITAL INPUT/OUTPUT					
Input Logic 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.

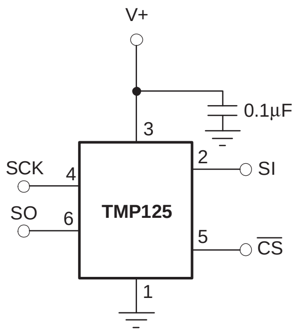


Figure 1. Typical Connections for the TMP125

COMMUNICATING WITH THE TMP125

The TMP125 continuously converts temperatures to digital data. Temperature data is read by pulling $\overline{\text{CS}}$ low. Once $\overline{\text{CS}}$ is pulled low, temperature data from the last completed conversion prior to dropping $\overline{\text{CS}}$ 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. Any portion of the 16-bit word can be read before raising $\overline{\text{CS}}$. However, all 16 bits must be clocked to allow shutdown of the TMP125. The TMP125 typically requires 60ms to complete a conversion, with results updated every 120ms.

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 summaraized 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

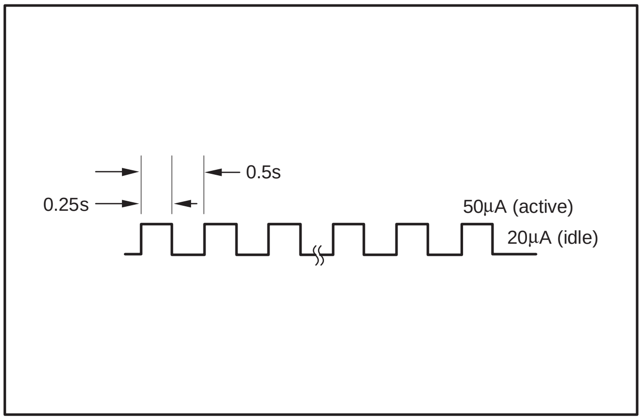


Figure 2. Conversion Time and Period

Timing Diagrams

The TMP125 is SPI-compatible. Figure 3 describes the output data of the TMP125. Figure 4, Figure 5, and Figure 6 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

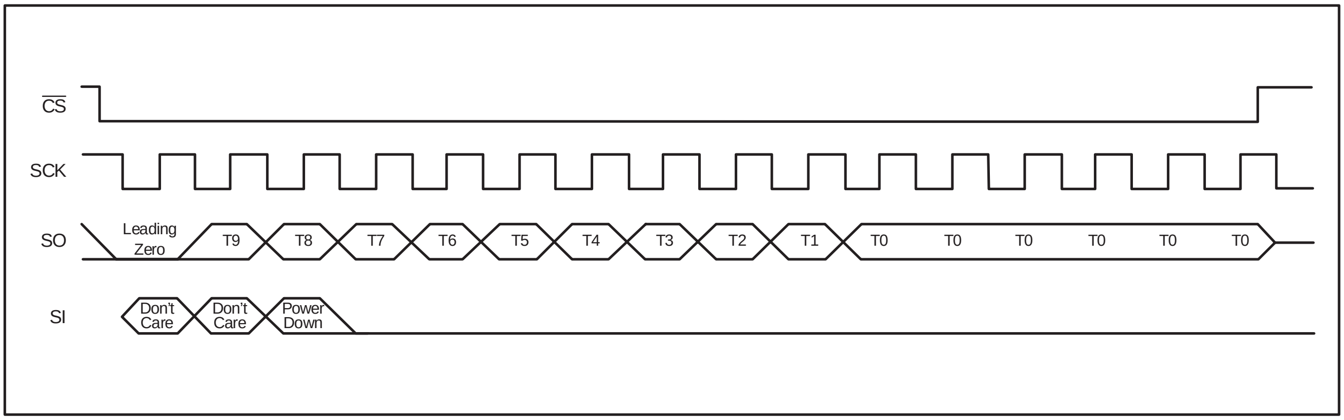


Figure 3. Data READ

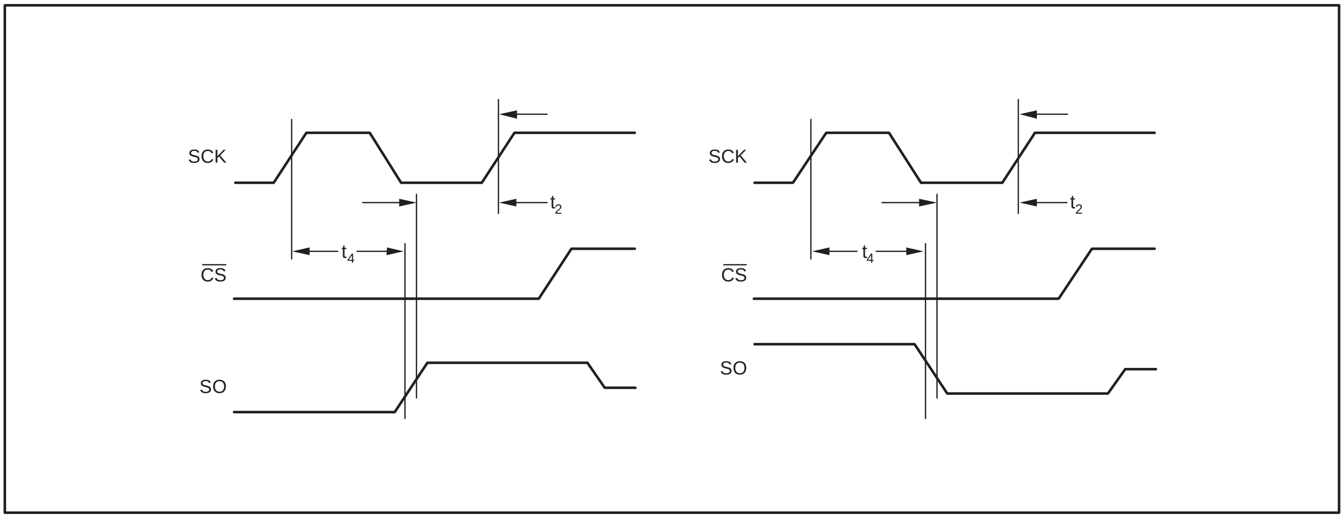


Figure 4. Input Data Timing Diagram

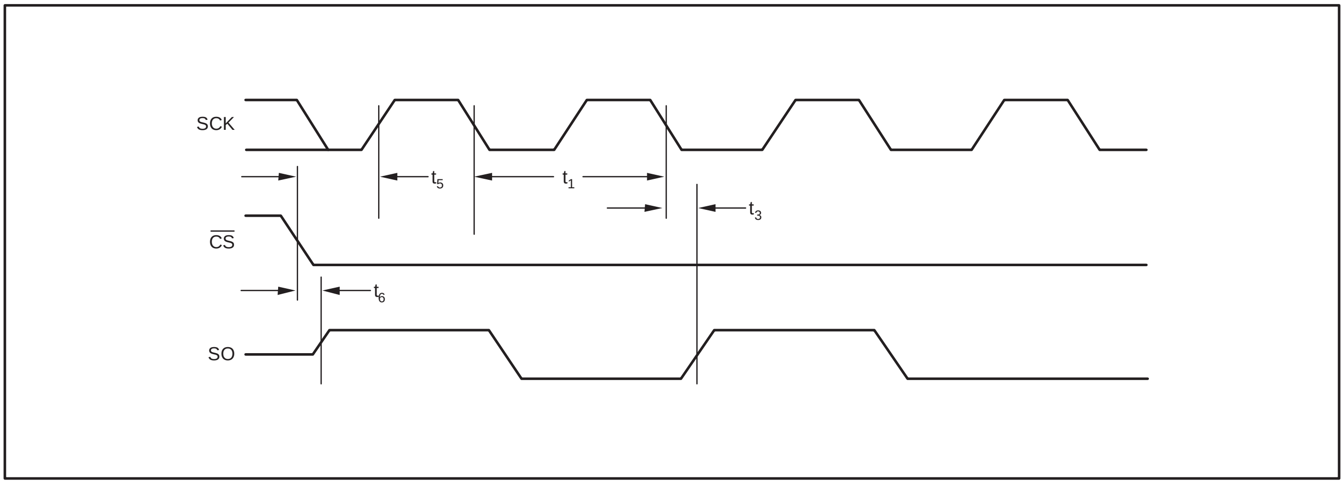


Figure 5. Output Data Timing Diagram

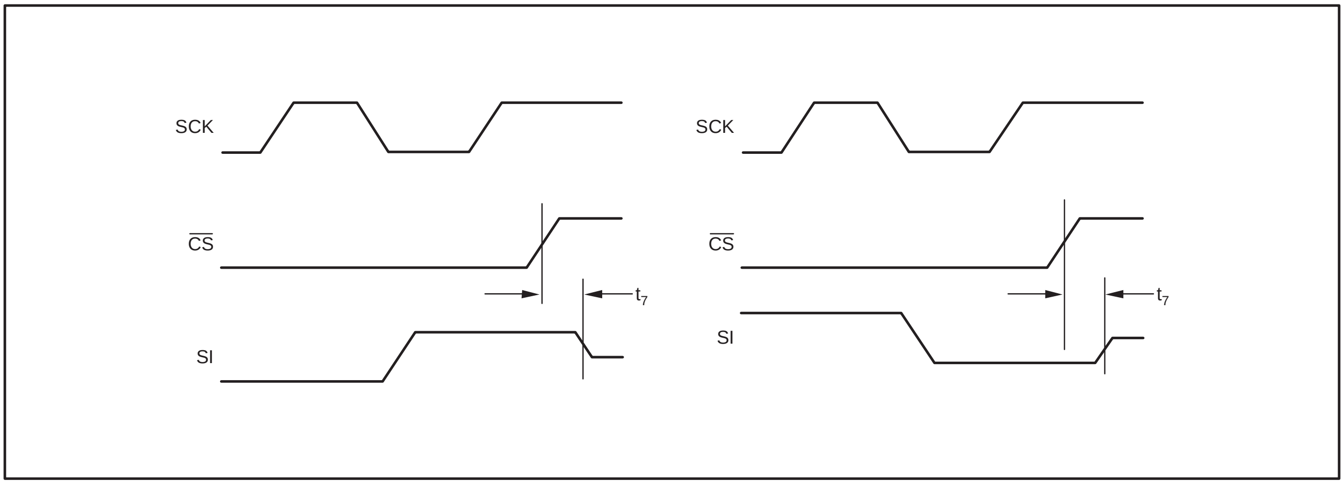


Figure 6. High Impedance Output Timing Diagram

PACKAGE OPTION ADDENDUM

11-Mar-2005

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
TMP125AIDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TMP125AIDBVRG4	ACTIVE	SOT-23	DBV	6	3000	None	Call TI	Call TI
TMP125AIDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

[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] Eco Plan - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
None: Not yet available Lead (Pb-Free).
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDECindustry standard classifications, and peak solder temperature.

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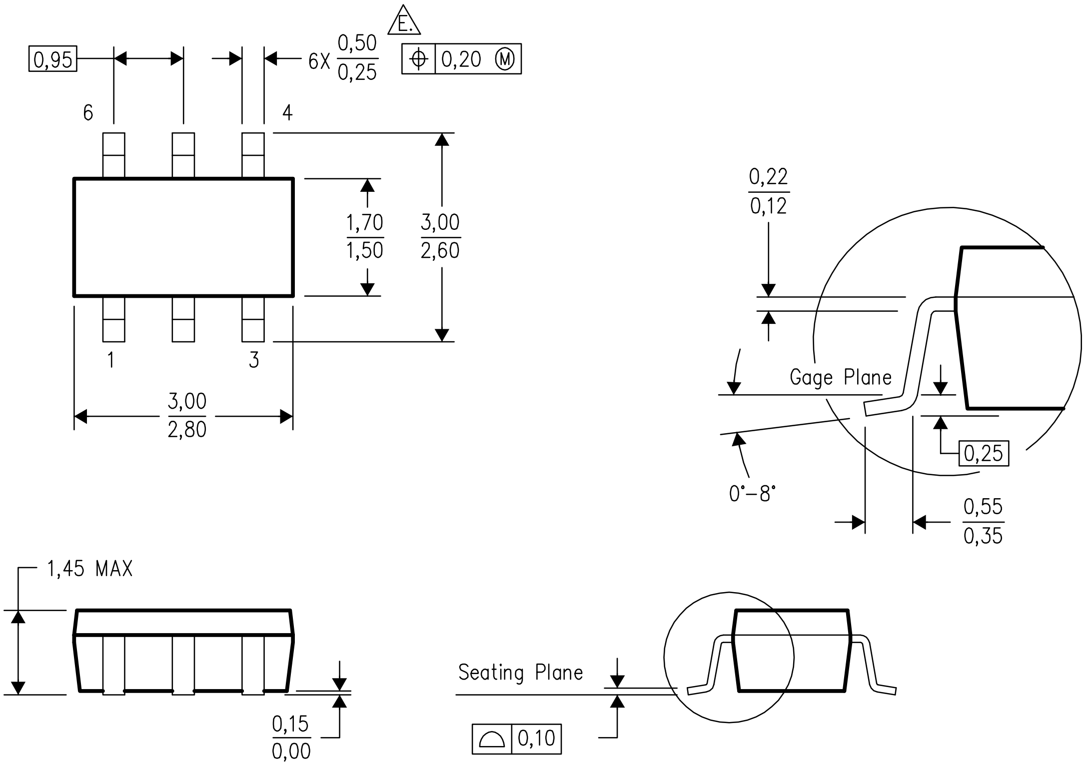
DBV (R–PDSO–G6) PLASTIC SMALL–OUTLINE PACKAGE



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NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion.
- D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- E. Falls within JEDEC MO–178 Variation AB, except minimum lead width.

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This file is the datasheet for the following electronic components:

TMP125AIDBVR - http://www.ti.com/product/tmp125aidbvr?HQS=TI-null-null-dscatalog-df-pf-null-wwe

TMP125 - http://www.ti.com/product/tmp125?HQS=TI-null-null-dscatalog-df-pf-null-wwe

TMP125AIDBVT - http://www.ti.com/product/tmp125aidbvt?HQS=TI-null-null-dscatalog-df-pf-null-wwe