TMP121
TMP123

SBOS273B – JUNE 2003 – REVISED SEPTEMBER 2003

1.5°C Accurate Digital Temperature Sensor with SPI™ Interface

FEATURES

- **DIGITAL OUTPUT: SPI-Compatible Interface**
- **RESOLUTION: 12-Bit + Sign, 0.0625°C**
- **ACCURACY: ±1.5°C from –25°C to +85°C (max)**
- **LOW QUIESCENT CURRENT: 50μA (max)**
- **WIDE SUPPLY RANGE: 2.7V to 5.5V**
- **TINY SOT23-6 PACKAGE**
- **OPERATION TO 150°C**

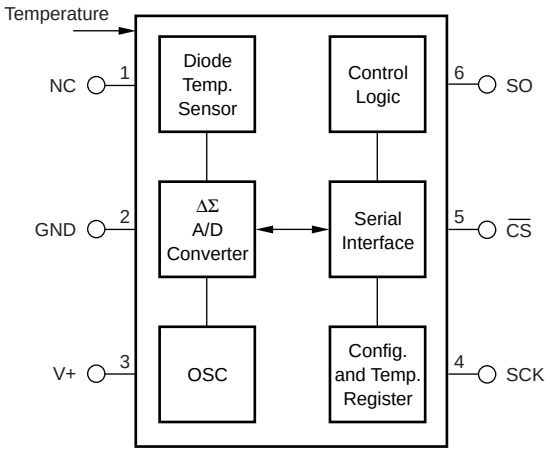
APPLICATIONS

- **POWER-SUPPLY TEMPERATURE MONITORING**
- **COMPUTER PERIPHERAL THERMAL PROTECTION**
- **NOTEBOOK COMPUTERS**
- **CELL PHONES**
- **BATTERY MANAGEMENT**
- **OFFICE MACHINES**

DESCRIPTION

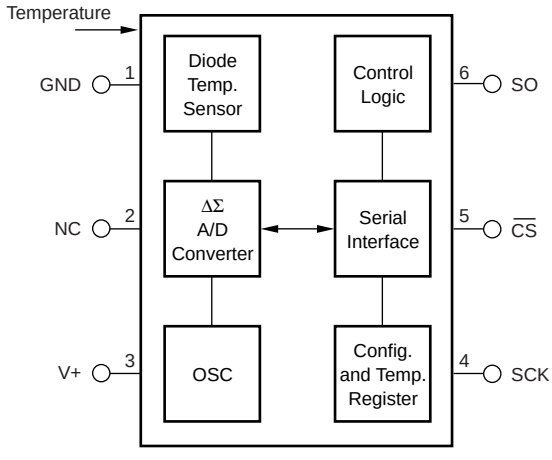
The TMP121 and TMP123 are SPI-compatible temperature sensors available in the tiny SOT23-6 package. Requiring no external components, the TMP121 and TMP123 are capable of measuring temperatures within 2°C of accuracy over a temperature range of –40°C to +125°C. Low supply current, and a supply range from 2.7V to 5.5V, make the TMP121 and TMP123 excellent candidates for low-power applications.

The TMP121 and TMP123 are ideal for extended thermal measurement in a variety of communication, computer, consumer, environmental, industrial, and instrumentation applications.



TMP121

NC = No Connection



TMP123

NC = No Connection

ABSOLUTE MAXIMUM RATINGS[1]

Power Supply, V+	7V
Input Voltage[2]	–0.3V to 7V
Input Current	10mA
Operating Temperature Range	–55°C to +150°C
Storage Temperature Range	–60°C to +150°C
Junction Temperature (T_J Max)	+150°C
Lead Temperature (soldering)	+300°C

NOTES: (1) Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability. (2) Input voltage rating applies to all TMP121 and TMP123 input voltages.

ELECTROSTATIC DISCHARGE SENSITIVITY

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.

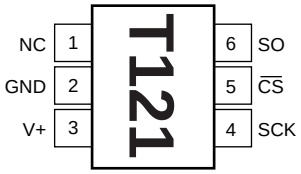
PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR[1]	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
TMP121	SOT23-6	DBV	–40°C to +125°C	T121	TMP121AIDBVT	Tape and Reel, 250
"	"	"	"	"	TMP121AIDBVR	Tape and Reel, 3000
TMP123	SOT23-6	DBV	–40°C to +125°C	T123	TMP123AIDBVT	Tape and Reel, 250
"	"	"	"	"	TMP123AIDBVR	Tape and Reel, 3000

NOTE: (1) For the most current specifications and package information, refer to our web site at www.ti.com.

PIN CONFIGURATIONS

Top View **SOT23-6**



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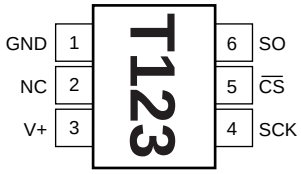


NC = No Connection

ELECTRICAL CHARACTERISTICS

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

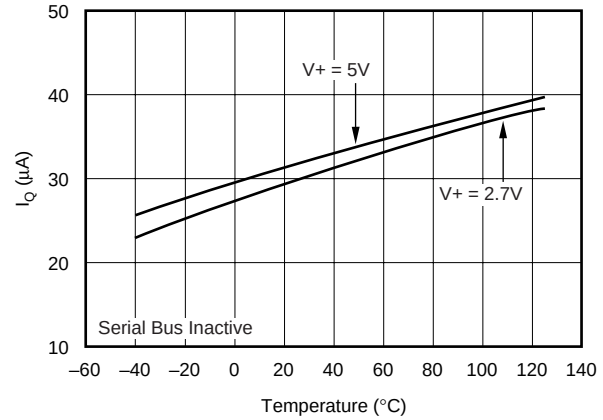
PARAMETER		CONDITION	TMP121, TMP123 MIN	TMP121, TMP123 TYP	TMP121, TMP123 MAX	UNITS
TEMPERATURE INPUT						
Range			–40		+125	°C
Accuracy (Temperature Error)		–25°C to +85°C		±0.5	±1.5	°C
		–40°C to +125°C		±1.0	±2.0	°C
		–40°C to +150°C		±1.5		°C
vs Supply			–0.3	0.1	+0.3	°C/V
Resolution				±0.0625		°C
DIGITAL INPUT/OUTPUT						
Input Logic Levels:						
V_{IH}			0.7(V+)			V
V_{IL}					0.3(V+)	V
Input Current, SO, 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
Resolution				12		Bits
Input Capacitance SO, SCK, $\overline{CS}$				2.5		pF
Conversion Time		12-Bit		240	320	ms
Conversion Period(1)		12-Bit		480	640	ms
POWER SUPPLY						
Operating Range			2.7		5.5	V
Quiescent Current	I_Q	Serial Bus Inactive		35	50	µA
Shutdown Current (TMP121)	I_{SD}	Serial Bus Inactive		0.1	1	µA
Shutdown Current (TMP123)	I_{SD}	Serial Bus Inactive		0.1	3	µA
TEMPERATURE RANGE						
Specified Range			–40		+125	°C
Operating Range			–55		+150	°C
Storage Range			–60		+150	°C
Thermal Resistance, θ_{JA}		SOT23-6 Surface-Mount		150		°C/W

NOTE: (1) Period indicates time between conversion starts.

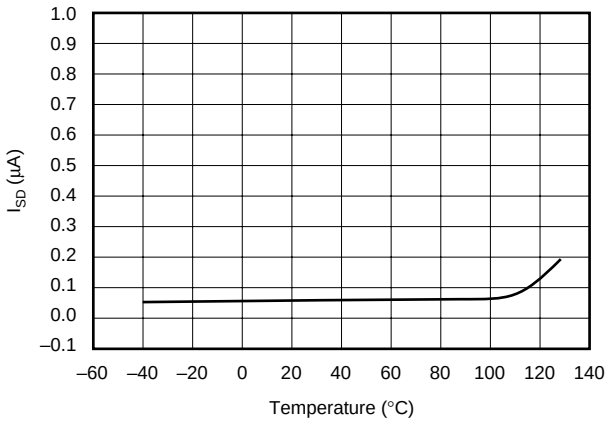
TYPICAL CHARACTERISTICS

At T_A = +25°C, and V+ = 5.0V, unless otherwise noted.

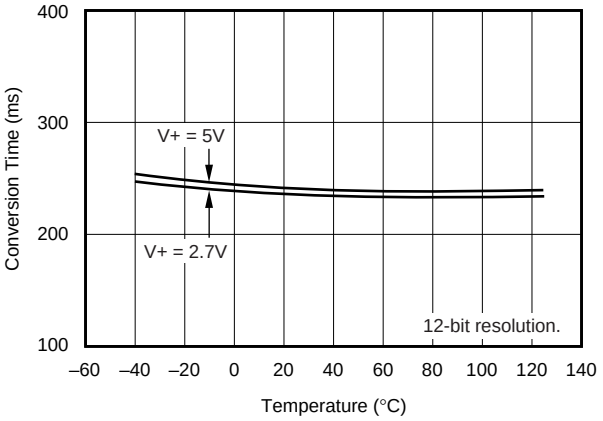
QUIESCENT CURRENT vs TEMPERATURE



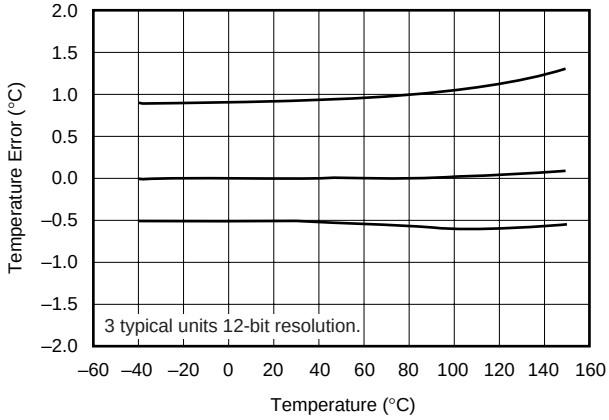
SHUTDOWN CURRENT vs TEMPERATURE



CONVERSION TIME vs TEMPERATURE



TEMPERATURE ACCURACY vs TEMPERATURE



APPLICATIONS INFORMATION

The TMP121 and TMP123 are 12-bit plus sign read-only digital temperature sensors optimal for thermal management and thermal protection applications. The TMP121 and the TMP123 communicate through a serial interface that is SPI compatible. Temperature is converted to a 12-bit plus sign data word with 0.0625°C resolution. The TMP121 and TMP123 are specified for a temperature range of –40°C to +125°C, with operation extending from –55°C to 150°C.

The TMP121 and TMP123 are optimal for low power applications, with a 0.5s conversion period for reduced power consumption. The TMP121 and TMP123 are specified for a supply voltage range of 2.7V to 5.5V, and also feature a hardware shutdown to provide additional power savings.

The TMP121 and TMP123 require no external components for operation, though a 0.1µF supply bypass capacitor is recommended. Figure 1 shows typical connections for the TMP121 and TMP123.

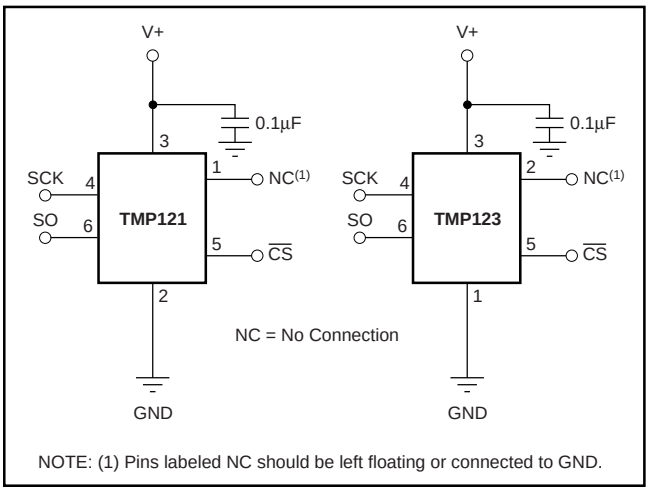


FIGURE 1. Typical Connections of the TMP121 and TMP123.

The sensing device of both the TMP121 and TMP123 is the chip itself; the die flag of the lead frame is connected to pin 2 of the TMP121, and of the TMP123. 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 GND pins of the TMP121 and TMP123 are directly connected to the metal lead frame, and are the best choice for thermal input.

To maintain accuracy in applications requiring air or surface temperature measurement, care should be taken to isolate the package and leads from ambient air temperature.

TEMPERATURE REGISTER

The Temperature Register of the TMP121 and TMP123 is a 16-bit, signed read-only register that stores the output of the most recent conversion. Up to 16 bits can be read to obtain data and are described in Table I. The first 13 bits are used to indicate temperature with bits D2 = 0, and D1, D0 in a high impedance state. Data format for temperature is summarized in Table II. 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
T12	T11	T10	T9	T8	T7	T6	T5

D7	D6	D5	D4	D3	D2	D1	D0
T4	T3	T2	T1	T0	0	Z	Z

TABLE I. Temperature Register.

TEMPERATURE (°C)	DIGITAL OUTPUT(1) (BINARY)	HEX
150	0100 1011 0000 0000	4B00
125	0011 1110 1000 0000	3E80
25	0000 1100 1000 0000	0C80
0.0625	0000 0000 0000 1000	0008
0	0000 0000 0000 0000	0000
–0.0625	1111 1111 1111 1000	FFF8
–25	1111 0011 1000 0000	F380
–55	1110 0100 1000 0000	E480

NOTE: (1) The last 2 bits are high impedance and are shown as 00 in the table.

TABLE II. Temperature Data Format.

COMMUNICATING WITH THE TMP121

The TMP121 and TMP123 continuously convert temperatures to digital data while $\overline{CS}$ is high. $\overline{CS}$ must be high for a minimum of one conversion time (320ms max) to update the temperature data. Reading temperature data from the TMP121 and TMP123 is initiated by pulling $\overline{CS}$ low, which will cause any conversion in progress to terminate, and place the device into analog shutdown. Quiescent current is reduced to 1µA during analog shutdown. 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. Any portion of the 16-bit word can be read before raising $\overline{CS}$. The TMP121 and TMP123 typically require 0.25s to complete a conversion and consume 50µA of current during this period. If $\overline{CS}$ is held high for longer than one conversion time period the TMP121 and TMP123 will go into idle mode for 0.25s, requiring only 20µA of current. A new conversion begins every 0.5s. Figure 2 describes the conversion timing for the TMP121 and TMP123.

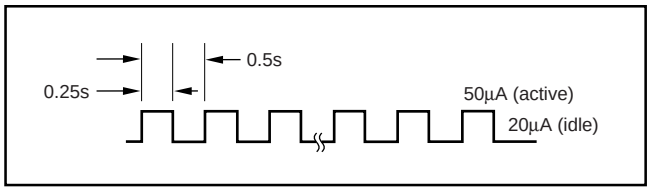


FIGURE 2. Conversion Time and Period.

The serial data of the TMP121 and TMP123 consists of 12-bit plus sign temperature data followed by a confirmation bit and two high impedance bits. Data is transmitted in two's complement format. Figure 3 describes the output data of the TMP121 and TMP123.

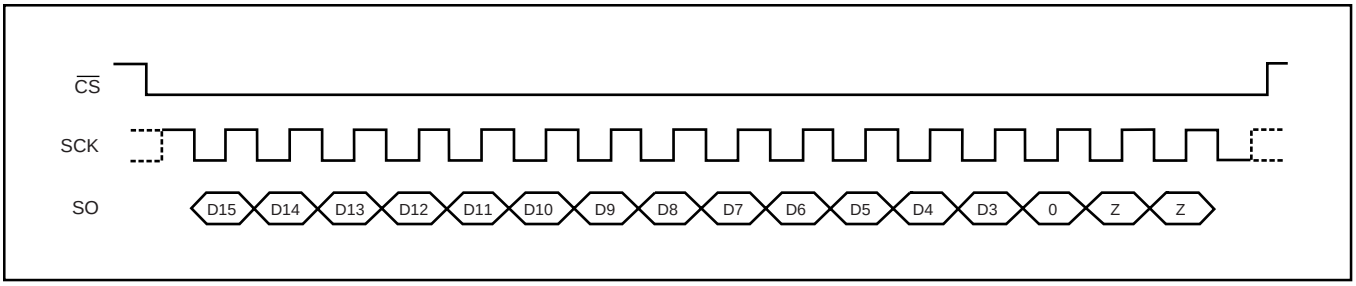


FIGURE 3. Data READ.

Timing Diagrams

The TMP121 and TMP123 are SPI compatible. Figures 4 and 5 describe the various timing requirements, with parameters defined in Table III.

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

TABLE III. Timing Description.

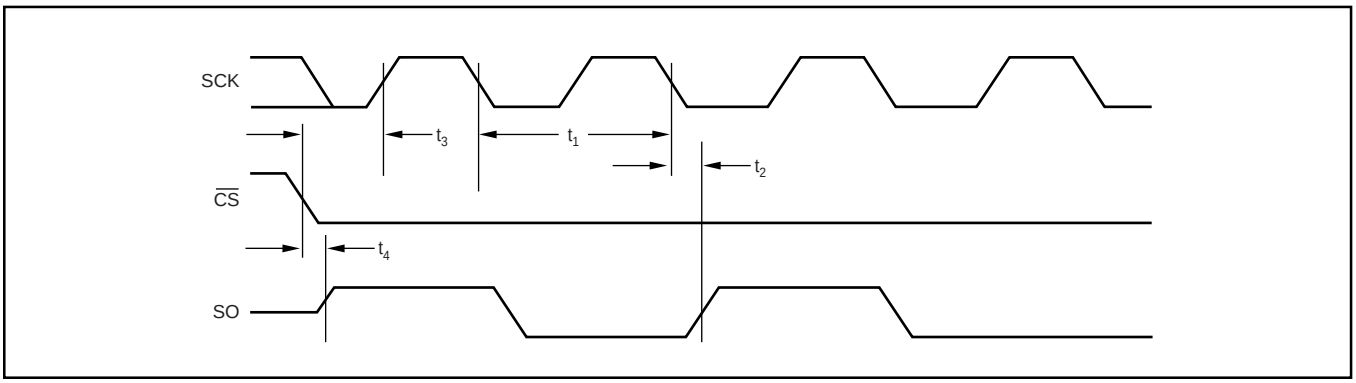


FIGURE 4. Output Data Timing Diagram.

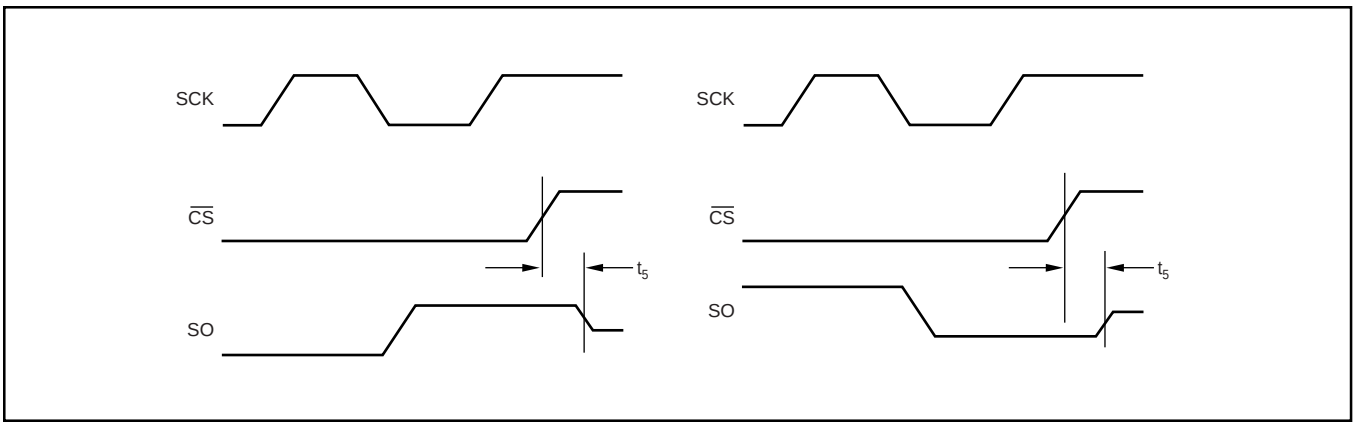


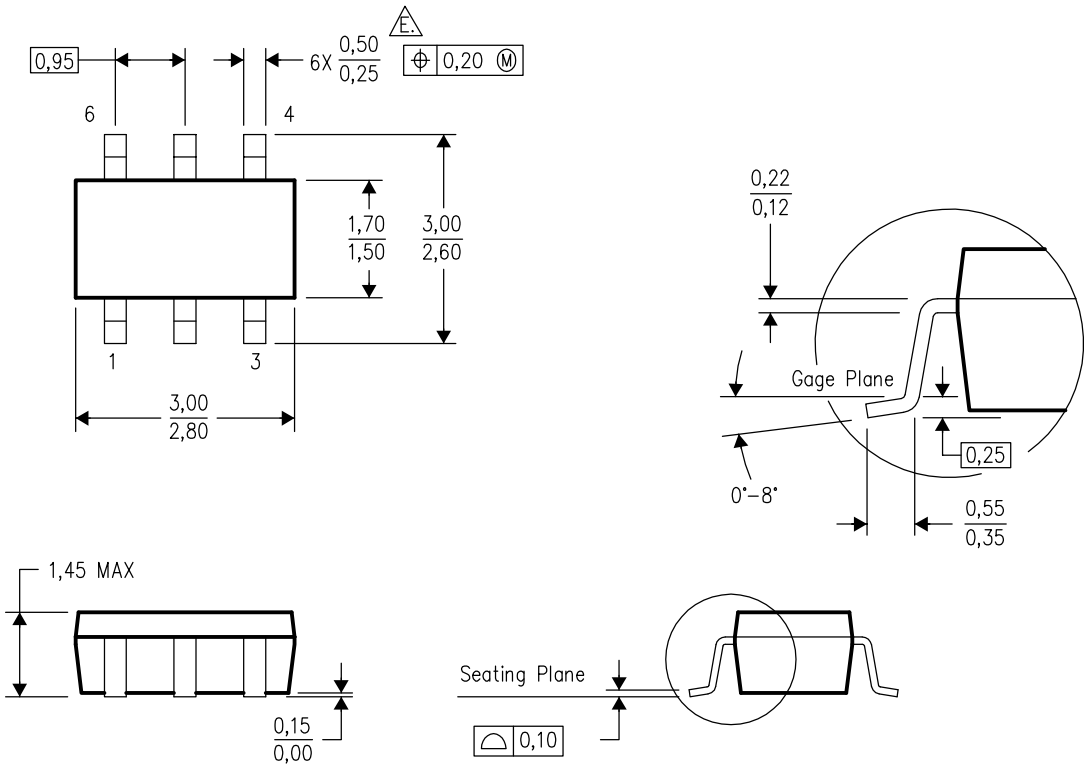
FIGURE 5. High Impedance Output Timing Diagram.

PACKAGING INFORMATION

ORDERABLE DEVICE	STATUS(1)	PACKAGE TYPE	PACKAGE DRAWING	PINS	PACKAGE QTY
TMP121AIDBVR	ACTIVE	SOP	DBV	6	3000
TMP121AIDBVT	ACTIVE	SOP	DBV	6	250
TMP123AIDBVR	ACTIVE	SOP	DBV	6	3000
TMP123AIDBVT	ACTIVE	SOP	DBV	6	250

(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.

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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