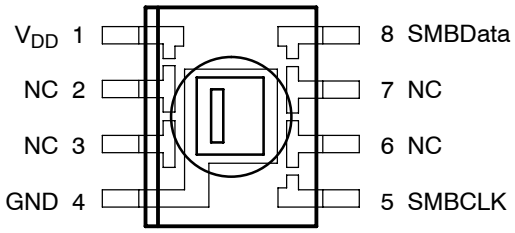
TSL2550
AMBIENT LIGHT SENSOR WITH SMBus INTERFACE

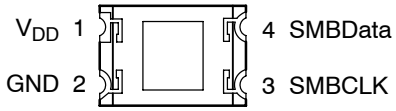
TAOS029L – OCTOBER 2007

- **Converts Light Intensity to Digital Signal**
- **Infrared Compensation to Approximate Human Eye Response**
- **Companding A/D for Wide Dynamic Range**
- **Rejects 50 Hz/60 Hz Lighting Ripple**
- **Two-Wire SMBus Serial Interface**
- **Single Supply Operation (2.7 V to 5.5 V)**
- **Low Active Power (1 mW typ)**
- **Power Down Mode**
- **Low-Profile Surface-Mount Packages**
- **RoHS Compliant**

PACKAGE D
8-LEAD SOIC
(TOP VIEW)



PACKAGE T
4-LEAD SMD
(TOP VIEW)



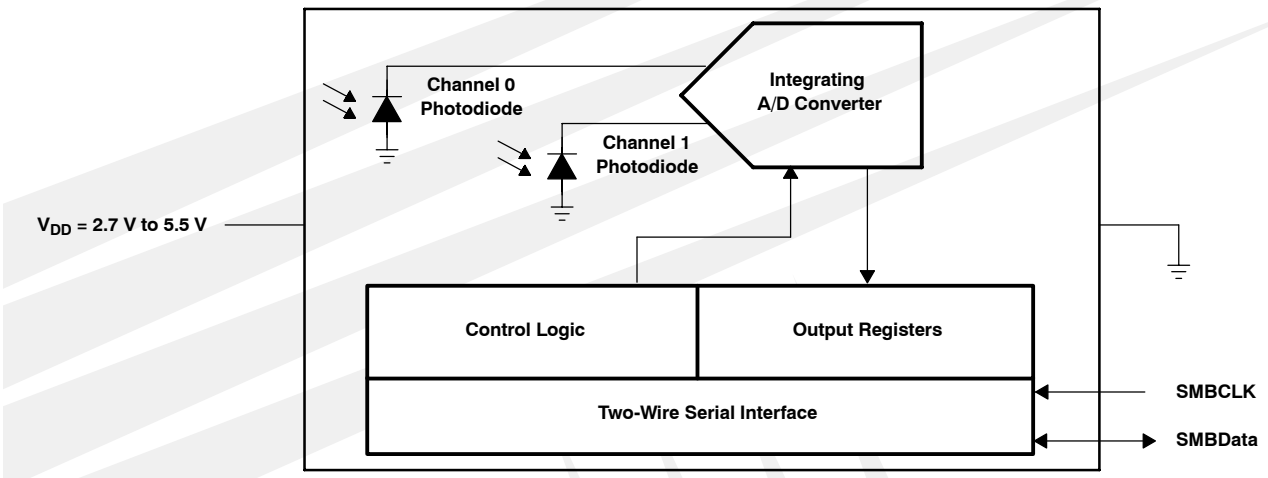
Description

The TSL2550 is a digital-output light sensor with a two-wire, SMBus serial interface. It combines two photodiodes and a companding analog-to-digital converter (ADC) on a single CMOS integrated circuit to provide light measurements over an effective 12-bit dynamic range with a response similar to that of the human eye.

The TSL2550 is designed for use with broad wavelength light sources. One of the photodiodes (channel 0) is sensitive to visible and infrared light, while the second photodiode (channel 1) is sensitive primarily to infrared light. An integrating ADC converts the photodiode currents to channel 0 and channel 1 digital outputs. Channel 1 digital output is used to compensate for the effect of the infrared component of ambient light on channel 0 digital output. The ADC digital outputs of the two channels are used to obtain a value that approximates the human eye response in the commonly used unit of Lux.

This device is intended primarily for use in applications in which measurement of ambient light is used to control display backlighting such as laptop computers, PDAs, camcorders, and GPS systems. Other applications include contrast control in LED signs and displays, camera exposure control, lighting controls, etc. The integrating conversion technique used by the TSL2550 effectively eliminates the effect of flicker from AC-powered lamps, increasing the stability of the measurement.

Functional Block Diagram



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Texas Advanced Optoelectronic Solutions Inc.
1001 Klein Road • Suite 300 • Plano, TX 75074 • (972) 673-0759
www.taosinc.com

Terminal Functions

TERMINAL NAME	D PKG NO.	T PKG NO.	TYPE	DESCRIPTION
GND	4	2		Power supply ground. All voltages are referenced to GND.
SMBCLK	5	3	I	SMBus serial clock input terminal — clock signal for SMBus serial data.
SMBData	8	4	I/O	SMBus serial data I/O terminal — serial data I/O for SMBus.
V_{DD}	1	1		Supply voltage.

Available Options

DEVICE	T_A	PACKAGE – LEADS	PACKAGE DESIGNATOR	ORDERING NUMBER
TSL2550	–40°C to 85°	SOIC–8	D	TSL2550D
TSL2550	–40°C to 85°	T–4	T	TSL2550T

Absolute Maximum Ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{DD} (see Note 1) . . . . . 6 V
Digital output voltage range, V_O . . . . . –0.3 V to +6 V
Digital output current, I_O . . . . . ±10 mA
SMBus input/output current, $I_{(SMBIN)}$ . . . . . –1 mA to 20 mA
Operating free-air temperature range, T_A . . . . . –40°C to 85°C
Storage temperature range, T_{stg} . . . . . –40°C to 85°C
ESD tolerance, human body model . . . . . 2000 V
Solder conditions in accordance with JEDEC J–STD–020A, maximum temperature (see Note 2) . . . 260°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltage values are with respect to GND.
2. **Package D only:** The device may be hand soldered provided that heat is applied only to the solder pad and no contact is made between the tip of the solder iron and the device lead. The maximum time heat should be applied to the device is 5 seconds.

Recommended Operating Conditions

	MIN	MAX	UNIT
Supply voltage, V_{DD}	2.7	5.5	V
Operating free-air temperature, T_A	0	70	°C
SMBus input low voltage @ V_{DD} = 3.3 V ± 5%, V_{IL}		0.8	V
SMBus input high voltage @ V_{DD} = 3.3 V ± 5%, V_{IH}	2.1		V
SMBus operating frequency, $f_{(SMBCLK)}$	10	100	kHz

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{OL}	SMBus output low voltage	I_O = 50 μA		0.01		V
		I_O = 4 mA			0.4	
I_{DD}	Supply current	Active, VSMBCLK and VSMDATA = V_{DD}, V_{DD} = 3.3 V ± 5%		0.35	0.6	mA
		Power down, VSMBCLK and VSMDATA = V_{DD}, V_{DD} = 3.3 V ± 5%			10	μA
I_{IH}	High level input current	VI = V_{DD}			5	μA
I_{IL}	Low level input current	VI = 0			–5	μA

Operating Characteristics, V_{DD} = 3.3 V, T_A = 25°C (unless otherwise noted) (see Notes 2, 3, 4)

PARAMETER		TEST CONDITIONS	CHANNEL	MIN	TYP	MAX	UNIT
	ADC count value, standard mode	E_e = 0	Ch0			1	counts
			Ch1			1	
		λ_p = 640 nm, E_e = 72 μW/cm²	Ch0	639	799	959	
			Ch1		85		
		λ_p = 940 nm, E_e = 140 μW/cm²	Ch0	511	799	1039	
			Ch1		703		
	ADC count value, extended mode	E_e = 0	Ch0			1	counts
			Ch1			1	
		λ_p = 640 nm, E_e = 72 μW/cm²	Ch0		155		
			Ch1		16		
		λ_p = 940 nm, E_e = 140 μW/cm²	Ch0		155		
			Ch1		139		
	ADC count value ratio: Ch1/Ch0, standard mode	λ_p = 640 nm, E_e = 72 μW/cm²		0.070	0.106	0.175	
		λ_p = 940 nm, E_e = 140 μW/cm²		0.70	0.88	1.20	
R_e	Irradiance responsivity, standard mode	λ_p = 640 nm, E_e = 72 μW/cm²	Ch0		11.1		counts/(μW/cm²)
			Ch1		1.2		
		λ_p = 940 nm, E_e = 140 μW/cm²	Ch0		5.7		
			Ch1		5		
R_v	Illuminance responsivity, standard mode	Fluorescent light source: 300 Lux	Ch0		2.8		counts/lux
			Ch1		0.23		
		Incandescent light source: 50 Lux	Ch0		19		
			Ch1		13		
	(Sensor Lux) / (actual Lux), standard mode (Note 5)	Fluorescent light source: 300 Lux		0.65	1	1.35	
		Incandescent light source: 50 Lux		0.5	1	1.5	

NOTES: 3. Optical measurements are made using small-angle incident radiation from light-emitting diode optical sources. Visible 640 nm LEDs and infrared 940 nm LEDs are used for final product testing for compatibility with high volume production.
4. The 640 nm irradiance E_e is supplied by an AlInGaP light-emitting diode with the following characteristics: peak wavelength λp = 640 nm and spectral halfwidth Δλ½ = 17 nm.
5. The 940 nm irradiance E_e is supplied by a GaAs light-emitting diode with the following characteristics: peak wavelength λp = 940 nm and spectral halfwidth Δλ½ = 40 nm.
6. The sensor Lux is calculated using the empirical formula shown on p. 11 of this data sheet based on measured Ch0 and Ch1 ADC count values for the light source specified. Actual Lux is obtained with a commercial luxmeter. The range of the (sensor Lux) / (actual Lux) ratio is estimated based on the variation of the 640 nm and 940 nm optical parameters. Devices are not 100% tested with fluorescent or incandescent light sources.

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AC Electrical Characteristics, V_{DD} = 3.3 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{(CONV)}$	Conversion time, per channel, standard mode			400		ms
$t_{(CONV)}$	Conversion time, per channel, extended mode			80		ms
$f_{(SMBCLK)}$	Clock frequency				100	kHz
$t_{(BUF)}$	Bus free time between start and stop condition		4.7			μs
$t_{(HDSTA)}$	Hold time after (repeated) start condition. After this period, the first clock is generated.		4			μs
$t_{(SUSTA)}$	Repeated start condition setup time		4.7			μs
$t_{(SUSTO)}$	Stop condition setup time		4			μs
$t_{(HDDAT)}$	Data hold time		300			ns
$t_{(SUDAT)}$	Data setup time		250			ns
$t_{(LOW)}$	SMBCLK clock low period		4.7			μs
$t_{(HIGH)}$	SMBCLK clock high period		4			μs
$t_{(TIMEOUT)}$	Detect clock/data low timeout		25		35	ms
t_F	Clock/data fall time				300	ns
t_R	Clock/data rise time				1000	ns
C_i	Input pin capacitance				10	pF

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PARAMETER MEASUREMENT INFORMATION

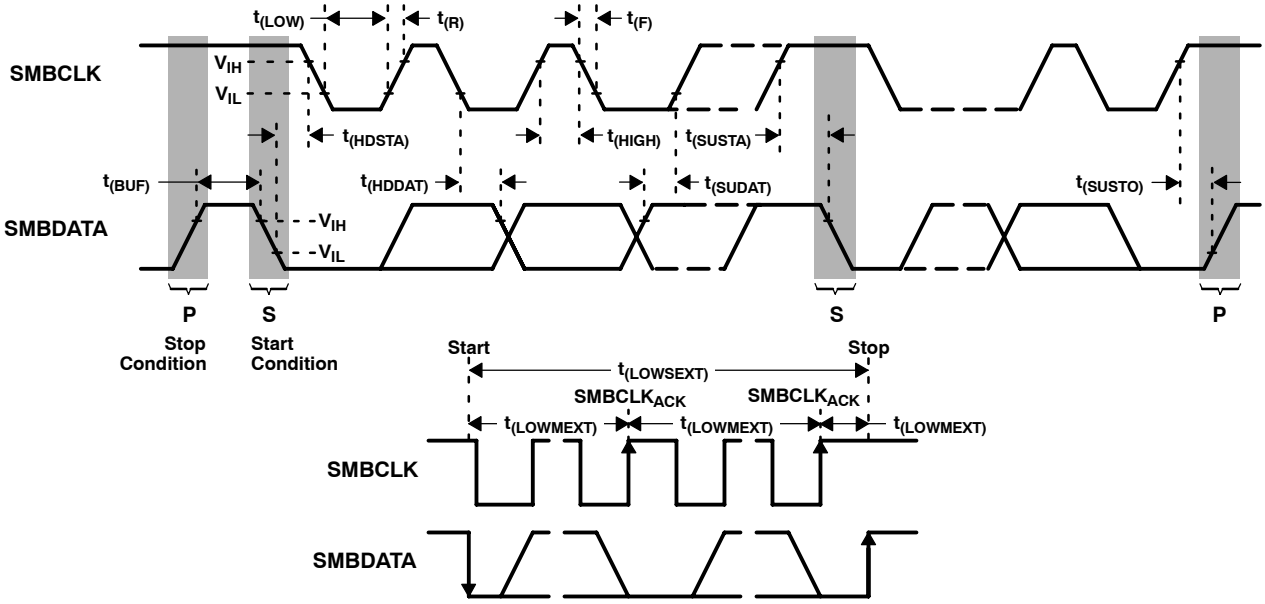


Figure 1. SMBus Timing Diagrams

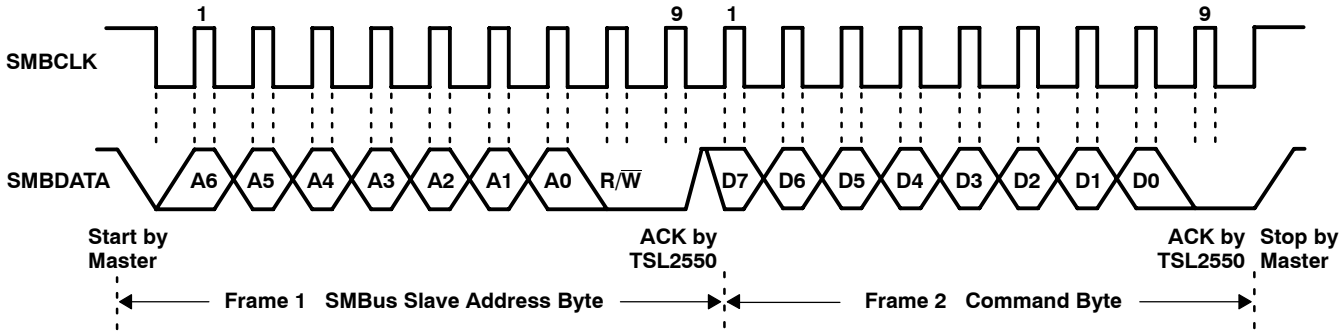


Figure 2. SMBus Timing Diagram for Send Byte Format

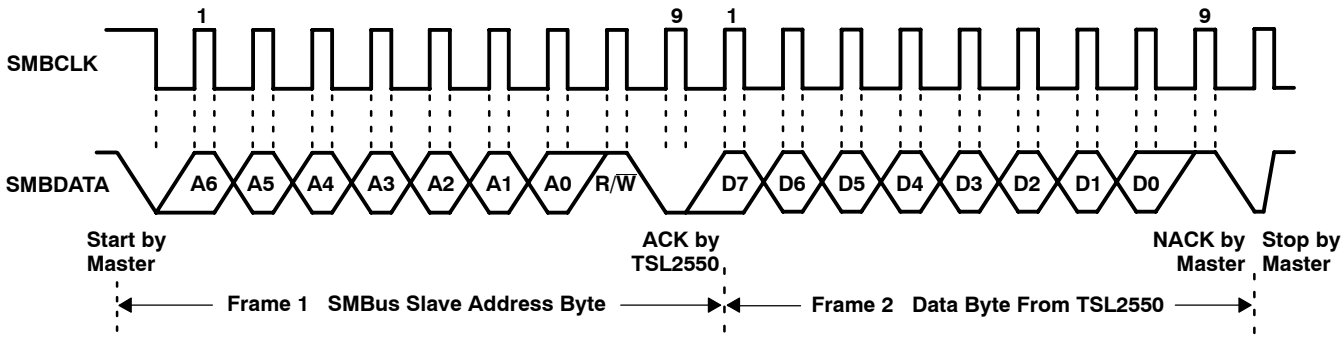


Figure 3. SMBus Timing Diagram for Receive Byte Format

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TYPICAL CHARACTERISTICS

SPECTRAL RESPONSIVITY

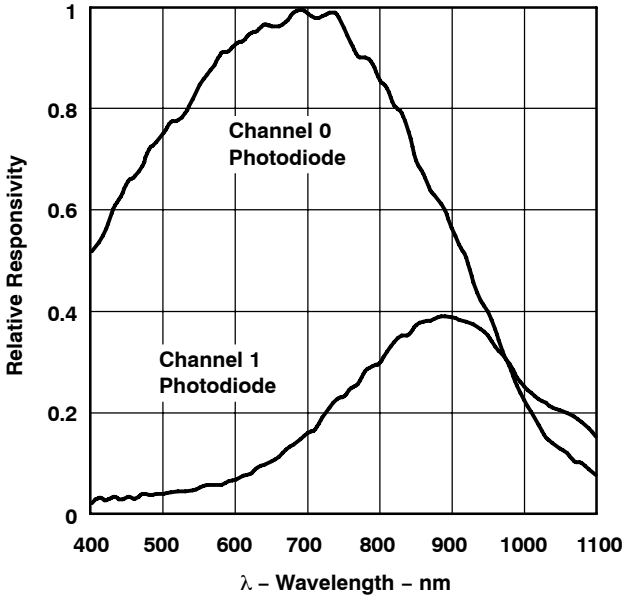


Figure 4

NORMALIZED ADC OUTPUT
vs.
SUPPLY VOLTAGE

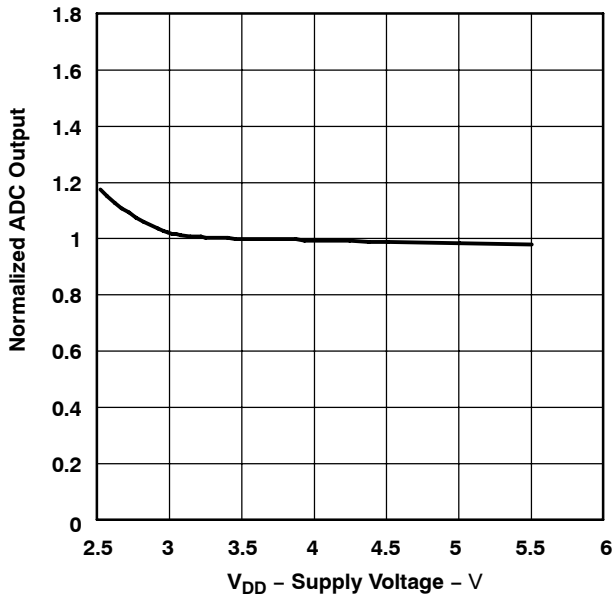


Figure 5

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PRINCIPLES OF OPERATION

Analog-to-Digital Converter

The TSL2550 contains an integrating analog-to-digital converter (ADC) that integrates a photodiode current. First it integrates channel 0 photodiode current and then it integrates channel 1 photodiode current. At the end of the conversion cycle for each channel, the conversion result is transferred to the appropriate channel 0 or channel 1 ADC register. The transfer is double-buffered to ensure that invalid data is not read during the transfer. After the data is transferred, the TSL2550 automatically begins the next conversion cycle. A VALID bit is used to indicate that data has been written to the ADC register after ADC is enabled.

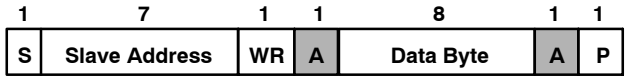
Interface to the ADC and control of other device functions is accomplished using the standard 2-wire System Management Bus (SMBus) interface. Both versions 1.1 and 2.0 of the SMBus are supported.

The ADC has two operating modes: *standard* and *extended*. In standard mode, the integration time is 400 mS for each channel or 800 mS for both channel 0 and channel 1. Extended mode shortens the integration time by a factor of five with a corresponding decrease in responsivity of 5×. The extended range allows the device to operate at higher light levels, extending the overall dynamic range by a factor of five.

Digital Interface

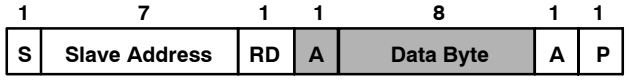
The TSL2550 contains an 8-bit command register that can be written and read via the SMBus. The command register controls the overall operation of the device. There are two read-only registers that contain the latest converted value of each of the two ADC channels. The SMBus slave address is hardwired internally as 0111001 (MSB to LSB, A6 to A0).

Both the *send byte protocol* and the *receive byte protocol* are implemented in the TSL2550. The send byte protocol allows single bytes of data to be written to the device (see Figure 6). The written byte is called the COMMAND byte. The receive byte protocol allows single bytes of data to be read from the device (see Figure 7). The receive data can be either the previously written COMMAND byte or the data from one of the ADC channels. In Figure 6 and Figure 7, the clear area represents data sent by the host and the shaded area represents data returned by the ambient light sensor or slave device.



S = Start Condition P = Stop Condition Shaded = Slave Transmission

Figure 6. Send Byte Protocol



S = Start Condition P = Stop Condition Shaded = Slave Transmission

Figure 7. Receive Byte Protocol

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Command Register

The command register is used primarily to:

- Select which ADC register will be read during a read cycle
- Switch the dynamic range of the device between standard and extended range modes
- Power the device up for operation or power it down for minimum power consumption

Table 1 shows the six primary commands used to control the TSL2550.

Table 1. Command Summary

COMMAND	FUNCTION
0x00h	Power-down state
0x03h	Power-up state/Read command register
0x1Dh	Write command to assert extended range mode
0x18h	Write command to reset or return to standard range mode
0x43h	Read ADC channel 0
0x83h	Read ADC channel 1

The content of the command register defaults to 0x00h when power is applied to the device, placing the device into the power-down mode.

Once the TSL2550 is set to the standard range mode (0x18h) or the extended range mode (0x1Dh), the device remains in that mode until it is powered down or the mode is changed via the command register.

The 0x03h command has two purposes: It is used to power up the device and can also be used to check that the device is communicating properly. The value returned during a read cycle should be 0x03h.

ADC Register

The TSL2550 contains two ADC registers (channel 0 and channel 1). Each ADC register contains two component fields that are used to determine the logarithmic ADC count value: CHORD bits and STEP bits. The CHORD bits correspond to the most significant portion of the ADC value and specifies a segment of the piece-wise linear approximation. The STEP bits correspond to the least significant portion of the ADC count value and specifies a linear value within a segment. CHORD and STEP bits all equal to 0 corresponds to a condition in which the light level is below the detection limit of the sensor. CHORD and STEP bits all equal to 1 corresponds to an overflow condition.

Each of the two ADC value registers contain seven data bits and a valid bit as described in Table 2.

Table 2. ADC Register Data Format

VALID	CHORD BITS			STEP BITS			
B7	B6	B5	B4	B3	B2	B1	B0
VALID	C2	C1	C0	S3	S2	S1	S0

FIELD	BITS	DESCRIPTION
VALID	7	ADC channel data is valid. One indicates that the ADC has written data into the channel data register, since ADCEN was asserted in the COMMAND register.
CHORD	6 to 4	CHORD number.
STEP	3 to 0	STEP number.

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The specific ADC value register read depends on the last read command written to the command register, as described above and in the *Operation* section, below.

The MSB of the ADC register (VALID bit B7) is used to indicate that data has been written to the ADC register after the device is powered up as described in *Command Register* section.

Bits 6 through 0 contain the 7-bit code representing the ADC count value, which is proportional to a photodetector current. In this code, the ADC count value is represented by a piece-wise linear approximation to a log function. The transfer function is broken into 8 chords of 16 steps each. (This code is very similar to μ-law code used in audio compression — it differs in that it does not have a sign bit and it is not inverted.) Table 3 shows the relationship between the CHORD and STEP bits and the CHORD and STEP numbers and values. These are used to calculate the ADC count value.

Table 3. CHORD and STEP Numbers and Values vs Register Bits

CHORD BITS B6, B5, B4	C, CHORD NUMBER	CHORD VALUE (Note A)	STEP VALUE (Note B)
000	0	0	1
001	1	16	2
010	2	49	4
011	3	115	8
100	4	247	16
101	5	511	32
110	6	1039	64
111	7	2095	128

STEP BITS B3, B2, B1, B0	S, STEP NUMBER
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	10
1011	11
1100	12
1101	13
1110	14
1111	15

NOTES: A. CHORD VALUE = INT $(16.5 \times ((2^C) - 1))$
B. STEP VALUE = 2^C

The ADC count value is obtained by adding the CHORD VALUE and the product of the STEP NUMBER and STEP VALUE (which depends on CHORD NUMBER).

$$\text{ADC Count Value} = ((\text{Chord Value}) + (\text{Step Value}) \times (\text{Step Number}))$$

The ADC count value can also be expressed as a formula:

$$\text{ADC Count Value} = (\text{INT}\ (16.5 \times ((2^C - 1))) + (S \times (2^C))$$

where:

C is the CHORD NUMBER (0 to 7)
S is the STEP NUMBER (0 to 15)
as defined in Table 3.

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Operation

After applying VDD, the device will initially be in the power down state. To operate the device, issue an SMBus Send Byte protocol with the device address and the appropriate command byte to read ADC channel 0 or ADC channel 1 (see Table 1). To obtain the conversion result, issue an SMBus Receive Byte protocol with the device address. The data byte received will correspond to the value in the ADC register (0 or 1) specified by the previous command. If a conversion has not been completed since power up (either through V_{DD} or power up command), the valid bit will be 0, and the data will not be valid. If there is a valid conversion result available, the valid bit will be set (1), and the remaining 7 bits will represent valid data from the previously selected ADC register. Data may be read repeatedly from the currently selected ADC register, and although it will remain valid, the ADC register will not be updated until a new conversion completes for that channel (800 ms total since there are two serial 400 ms per channel conversion times in standard mode). Note also that the command register itself may be read, as a check to be sure that the device is communicating properly.

To power down the device for reduced power consumption, issue an SMBus Send Byte protocol with the device address followed by 0 as indicated in Table 1.

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APPLICATION INFORMATION

The TSL2550 is intended for use in ambient light detection applications, such as display backlight control, where adjustments are made to display brightness or contrast based on the brightness of the ambient light, as perceived by the human eye. Conventional silicon detectors respond strongly to infrared light, which the human eye does not see. This can lead to significant error when the infrared content of the ambient light is high, such as with incandescent lighting, due to the difference between the silicon detector response and the brightness perceived by the human eye.

This problem is overcome in the TSL2550 through the use of two photodiodes. One of the photodiodes (channel 0) is sensitive to both visible and infrared light, while the second photodiode (channel 1) is sensitive primarily to infrared light. An integrating ADC converts the photodiode currents to channel 0 and channel 1 digital outputs. Channel 1 digital output is used to compensate for the effect of the infrared component of light on the channel 0 digital output. The ADC digital outputs from the two channels are used in a formula to obtain a value that approximates the human eye response in the commonly used Illuminance unit of Lux. For standard mode:

$$\text{Light Level (lux)} = (\text{Ch0} - \text{Ch1}) \times 0.39 \times e^{(-0.181R^2)}$$

where:

R = Ch1 Counts / (Ch0 Counts – Ch1 Counts)

The formula above was obtained by optical testing with fluorescent and incandescent light sources. The light level calculated from the formula will be slightly higher than the actual light level for sunlight and will be slightly lower than the actual light level for composite fluorescent and incandescent light sources.

NOTE:

Please see TAOS application notes for additional information, including implementing a display brightness control system with the TSL2550, and for a simple implementation of the equation shown above suitable for use in embedded microcontrollers.

Table 4 contains a summary of the typical sensor outputs for several common light sources.

Table 4. Sensor Output Summary (Standard Mode)

LIGHT SOURCE	ILLUMINANCE (LUX)	CHANNEL 0 (COUNTS)	CHANNEL 1 (COUNTS)	RATIO: CH1/CH0	LUX per CH0 COUNT
Fluorescent	297	831	68	0.082	0.36
Daylight (shade)	201	895	343	0.383	0.22
Incandescent	42	959	671	0.7	0.04

Light from 50 or 60 Hz sources, and especially fluorescent lighting, has a high harmonic content. Since the TSL2550 integrates the ambient light over an approximately 400 millisecond interval (per channel), this light ripple is typically reduced to less than ¼ LSB.

Power Supply Decoupling

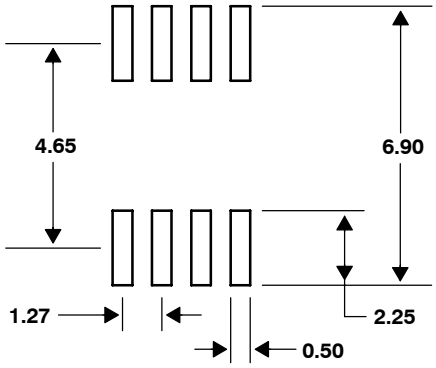
The power supply lines must be decoupled with a 0.1 μF capacitor placed as close to the device package as possible. The bypass capacitor should have low effective series resistance (ESR) and effective series inductance (ESI), such as the common ceramic types, which provide a low impedance path to ground at high frequencies to handle transient currents caused by internal logic switching.

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APPLICATION INFORMATION

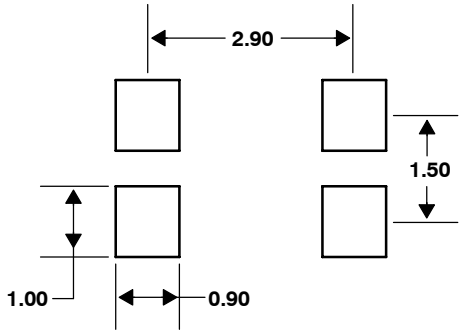
PCB Pad Layout

Suggested PCB pad layout guidelines for the D package and T package are shown in Figure 8 and Figure 9.



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.

Figure 8. Suggested D Package PCB Layout



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.

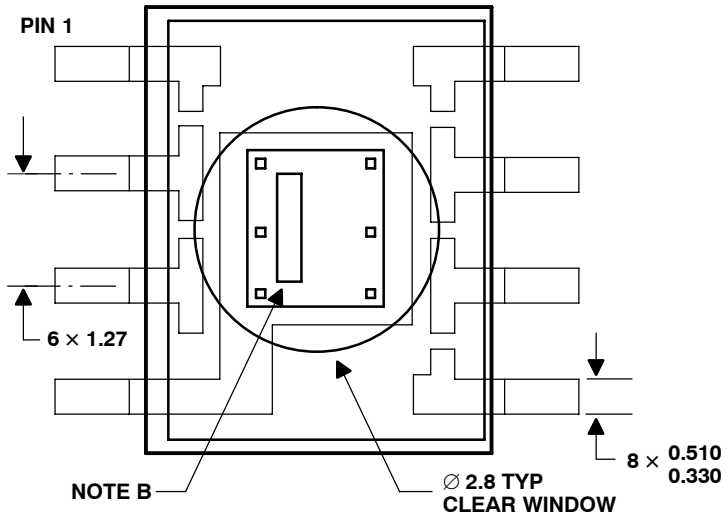
Figure 9. Suggested T Package PCB Layout

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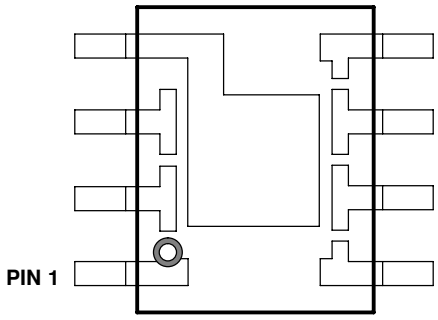
MECHANICAL DATA

PACKAGE D **Plastic Small-Outline**

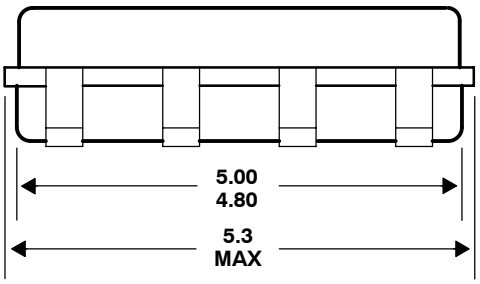
TOP VIEW



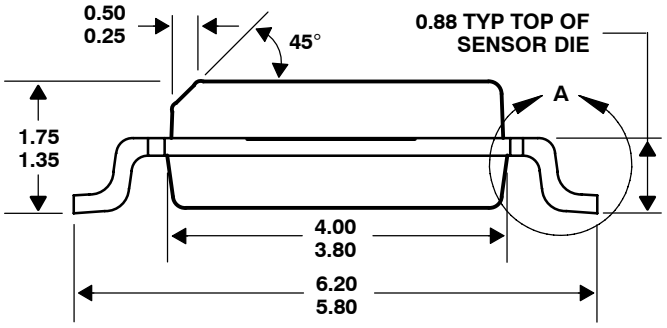
BOTTOM VIEW

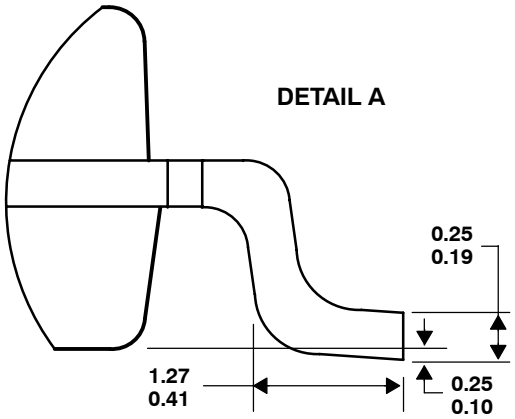


SIDE VIEW



END VIEW





NOTES: A. All linear dimensions are in millimeters.
B. The center of the 1234 μm by 282 μm photo-active area is typically located in the center of the package in the long dimension and 269 μm off center in the short dimension.
C. Package is molded with an electrically nonconductive clear plastic compound having an index of refraction of 1.55.
D. This drawing is subject to change without notice.

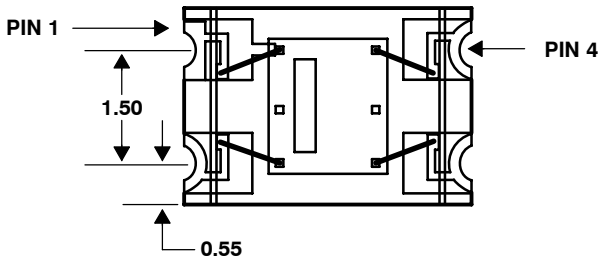
Figure 10. Package D — Plastic Small Outline IC Packaging Configuration

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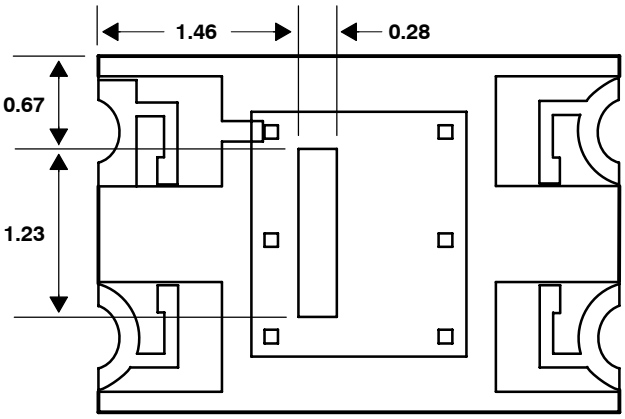
MECHANICAL DATA

PACKAGE T **Four-Lead Surface Mount Device**

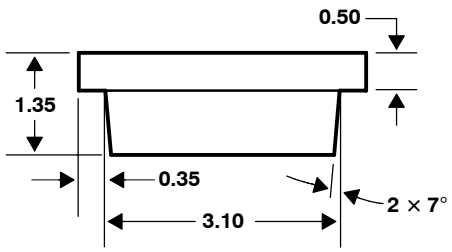
TOP VIEW



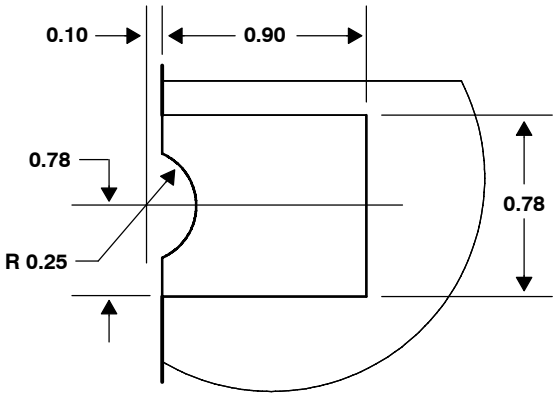
PHOTODIODE ACTIVE AREA LOCATION



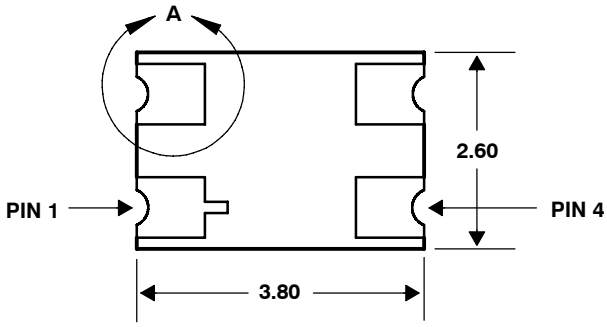
SIDE VIEW



DETAIL A: TYPICAL PACKAGE TERMINAL



BOTTOM VIEW

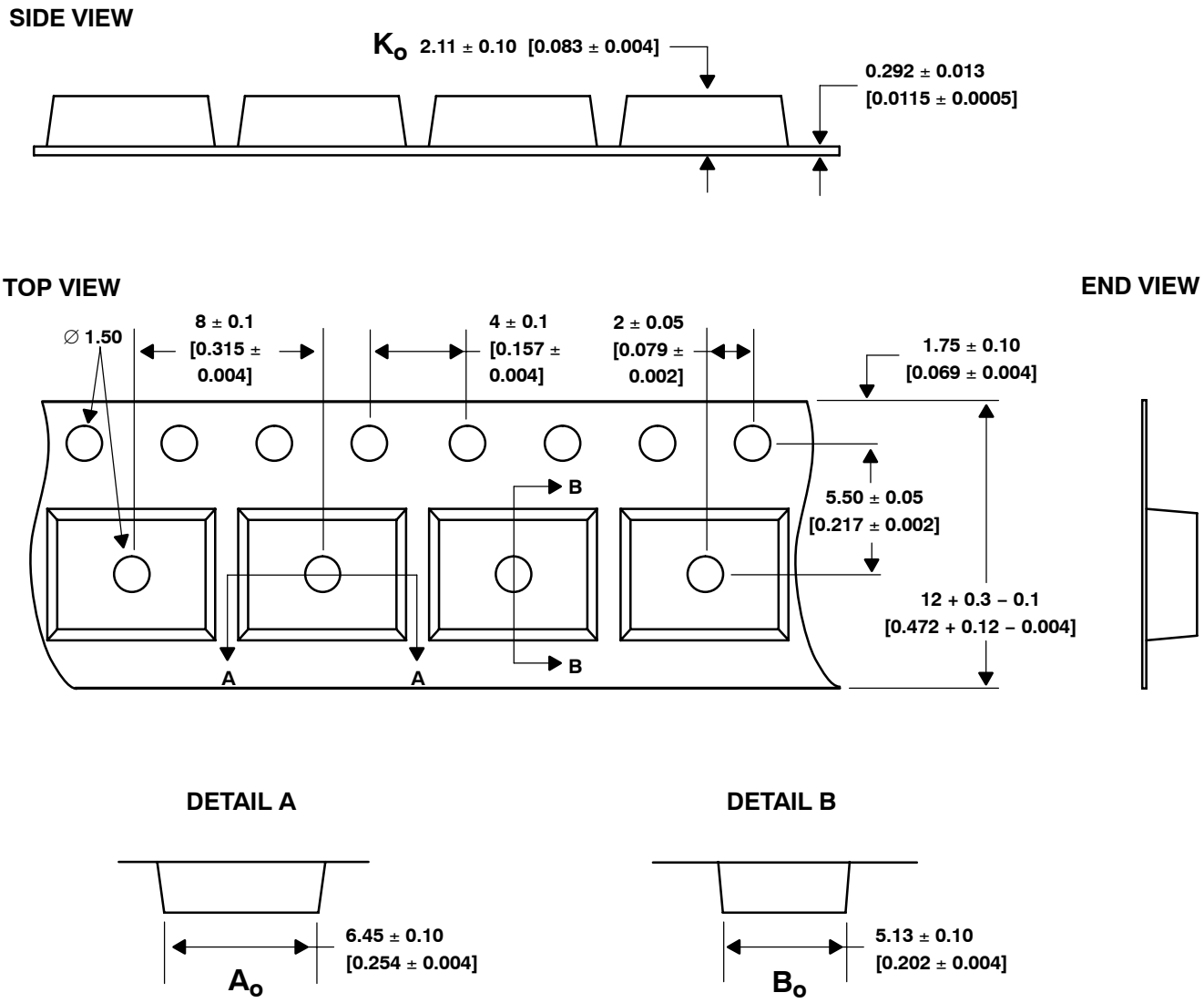


NOTES: A. All linear dimensions are in millimeters.
B. Terminal finish is gold.
C. Dimension tolerance is ± 0.15 mm.
D. This drawing is subject to change without notice.

Figure 11. Package T — Four-Lead Surface Mount Device Packaging Configuration

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MECHANICAL DATA

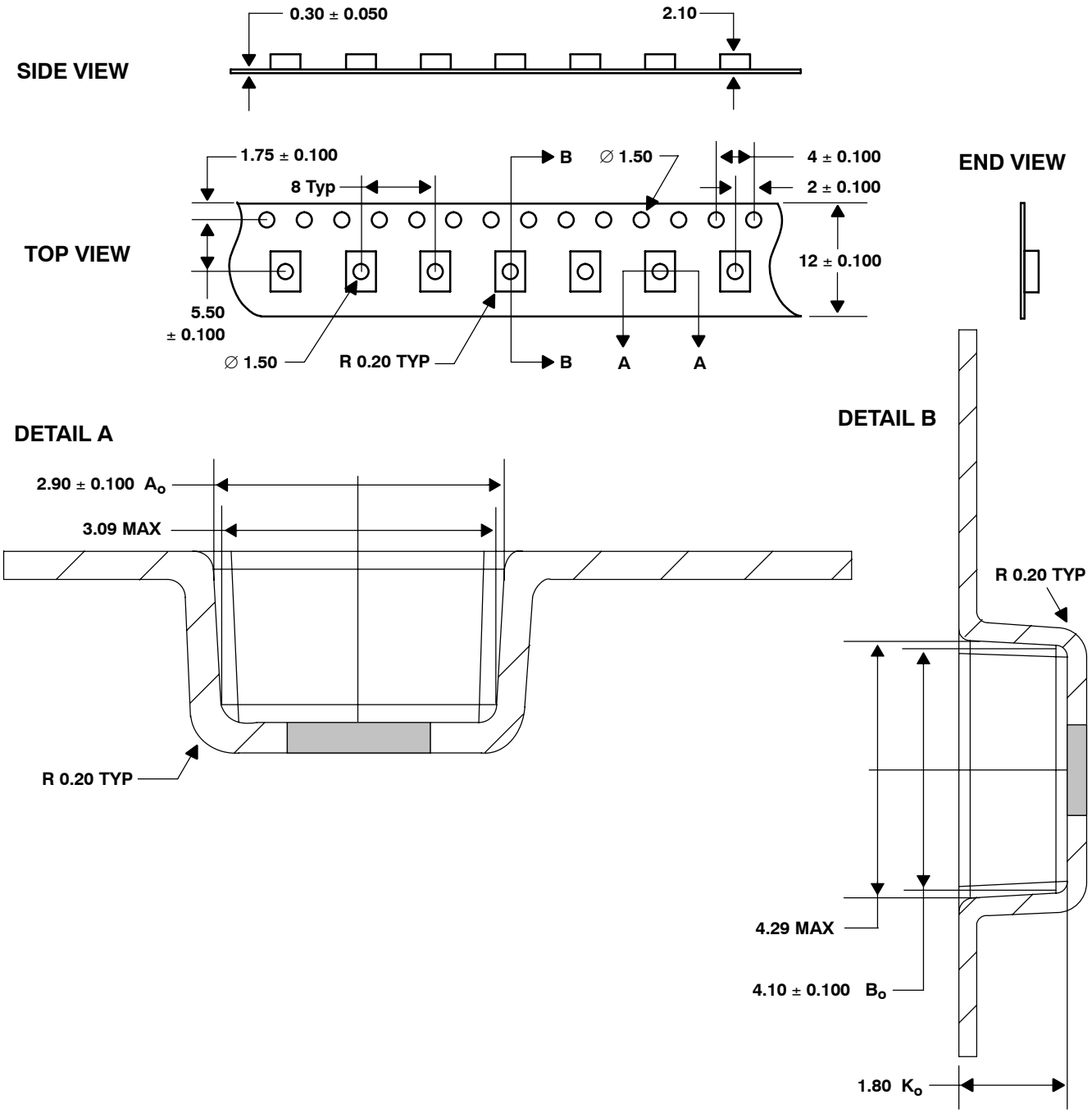


NOTES: A. All linear dimensions are in millimeters [inches].
B. The dimensions on this drawing are for illustrative purposes only. Dimensions of an actual carrier may vary slightly.
C. Symbols on drawing A_o, B_o, and K_o are defined in ANSI EIA Standard 481–B 2001.
D. Each reel is 178 millimeters in diameter and contains 1000 parts.
E. TAOS packaging tape and reel conform to the requirements of EIA Standard 481–B.
F. In accordance with EIA standard, device pin 1 is located next to the sprocket holes in the tape.
G. This drawing is subject to change without notice.

Figure 12. Package D Carrier Tape

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MECHANICAL DATA



NOTES:
A. All linear dimensions are in millimeters.
B. The dimensions on this drawing are for illustrative purposes only. Dimensions of an actual carrier may vary slightly.
C. Symbols on drawing A_o, B_o, and K_o are defined in ANSI EIA Standard 481–B 2001.
D. Each reel is 178 millimeters in diameter and contains 1000 parts.
E. TAOS packaging tape and reel conform to the requirements of EIA Standard 481–B.
F. In accordance with EIA standard, device pin 1 is located next to the sprocket holes in the tape.
G. This drawing is subject to change without notice.

Figure 13. Package T Carrier Tape

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MANUFACTURING INFORMATION

The D and T packages have been tested and have demonstrated an ability to be reflow soldered to a PCB substrate. The process, equipment, and materials used in these test are detailed below.

The solder reflow profile describes the expected maximum heat exposure of components during the solder reflow process of product on a PCB. Temperature is measured on top of component. The components should be limited to a maximum of three passes through this solder reflow profile.

Table 5. TSL2550 Solder Reflow Profile

PARAMETER	REFERENCE	TSL2550D/TSL2550T
Average temperature gradient in preheating		2.5°C/sec
Soak time	t_{soak}	2 to 3 minutes
Time above 217°C	t_1	Max 60 sec
Time above 230°C	t_2	Max 50 sec
Time above T_{peak} –10°C	t_3	Max 10 sec
Peak temperature in reflow	T_{peak}	260° C (–0°C/+5°C)
Temperature gradient in cooling		Max –5°C/sec

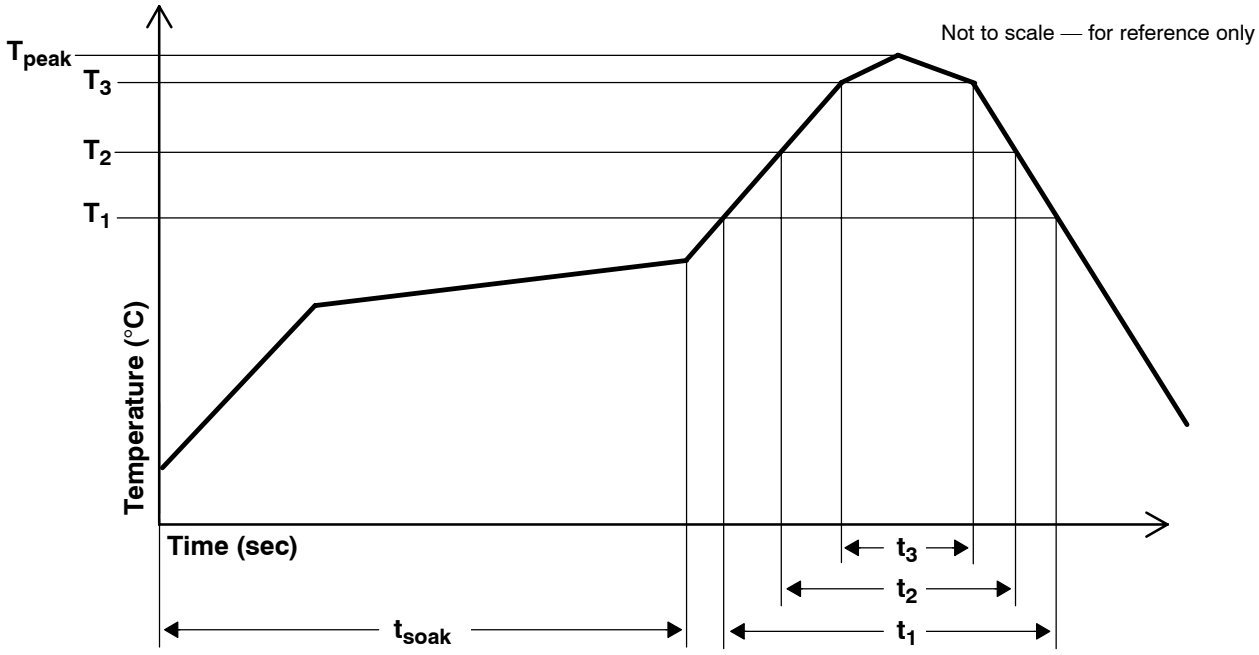


Figure 14. TSL2550D/TSL2550T Solder Reflow Profile Graph

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MANUFACTURING INFORMATION

Moisture Sensitivity

Optical characteristics of the device can be adversely affected during the soldering process by the release and vaporization of moisture that has been previously absorbed into the package molding compound.

Package D

To ensure the package molding compound contains the smallest amount of absorbed moisture possible, all devices shipped in carrier tape have been pre-baked and shipped in a sealed moisture-barrier bag. No further action is necessary if these devices are processed through solder reflow within 24 hours of the seal being broken on the moisture-barrier bag.

However, for all devices shipped in tubes or if the seal on the moisture barrier bag has been broken for 24 hours or longer, it is recommended that the following procedures be used to ensure the package molding compound contains the smallest amount of absorbed moisture possible.

For devices shipped in tubes:

1. Remove devices from tubes
2. Bake devices for 4 hours, at 90°C
3. After cooling, load devices back into tubes
4. Perform solder reflow within 24 hours after bake

Bake only a quantity of devices that can be processed through solder reflow in 24 hours. Devices can be re-baked for 4 hours, at 90°C for a cumulative total of 12 hours (3 bakes for 4 hours at 90°C).

For devices shipped in carrier tape:

1. Bake devices for 4 hours, at 90°C in the tape
2. Perform solder reflow within 24 hours after bake

Bake only a quantity of devices that can be processed through solder reflow in 24 hours. Devices can be re–baked for 4 hours in tape, at 90°C for a cumulative total of 12 hours (3 bakes for 4 hours at 90°C).

Package T

To ensure the package molding compound contains the smallest amount of absorbed moisture possible, each device is dry-baked prior to being packed for shipping. Devices are packed in a sealed aluminized envelope with silica gel to protect them from ambient moisture during shipping, handling, and storage before use.

The T package has been assigned a moisture sensitivity level of MSL 3 and the devices should be stored under the following conditions:

Temperature Range	5°C to 50°C
Relative Humidity	60% maximum
Total Time	6 months from the date code on the aluminized envelope — if unopened
Opened Time	168 hours or fewer

Rebaking will be required if the devices have been stored unopened for more than 6 months or if the aluminized envelope has been open for more than 168 hours. If rebaking is required, it should be done at 90°C for 4 hours.

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