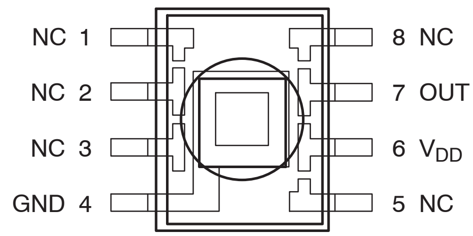
- **Monolithic Silicon IC Containing Photodiode, Operational Amplifier, and Feedback Components**
- **Converts Light Intensity to a Voltage**
- **High Irradiance Responsivity, Typically**
  - **64 mV/(μW/cm^2) at λ_p = 640 nm (TSL250RD)**
  - **58 mV/(μW/cm^2) at λ_p = 940 nm (TSL260RD)**
- **Single Voltage Supply Operation**
- **Low Dark (Offset) Voltage . . . 10 mV Max**
- **Low Supply Current . . . 1.1 mA Typical**
- **Wide Supply-Voltage Range . . . 2.7 V to 5.5 V**
- **Low-Profile Surface-Mount Package:**
  - **Clear Plastic for TSL250RD and TSL251RD**
  - **Visible Light-Cutoff Filter Plastic for TSL260RD and TSL261RD**
- **Lead (Pb) Free and RoHS Compliant Package**

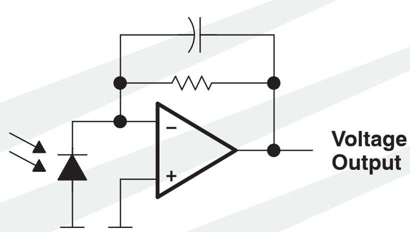
PACKAGE D
8-LEAD SOIC
(TOP VIEW)



Description

The TSL250RD, TSL251RD, TSL260RD, and TSL261RD are light-to-voltage optical sensors, each combining a photodiode and a transimpedance amplifier on a single monolithic IC. The TSL250RD and TSL260RD have an equivalent feedback resistance of 16 MΩ and a photodiode measuring 1 square mm. The TSL251RD and TSL261RD have an equivalent feedback resistance of 8 MΩ and a photodiode measuring 0.5 square mm. Output voltage is directly proportional to the light intensity (irradiance) on the photodiode. These devices have improved amplifier offset-voltage stability and low power consumption.

Functional Block Diagram



Terminal Functions

TERMINAL NAME	TERMINAL NO.	DESCRIPTION
GND	4	Ground (substrate). All voltages are referenced to GND.
OUT	7	Output voltage.
V_{DD}	6	Supply voltage.

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

Supply voltage, V_{DD} (see Note 1) . . . . 6 V
Output current, I_O . . . . ±10 mA
Duration of short-circuit current at (or below) 25°C (see Note 2) . . . . 5 s
Operating free-air temperature range, T_A . . . . −25°C to 85°C
Storage temperature range, T_{stg} . . . . −25°C to 85°C
Solder conditions in accordance with JEDEC J−STD−020A, maximum temperature (see Note 3) . . . 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 voltages are with respect to GND.
2. Output may be shorted to supply.
3. 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	NOM	MAX	UNIT
Supply voltage, V_{DD}	2.7		5.5	V
Operating free-air temperature, T_A	0		70	°C

Electrical Characteristics at V_{DD} = 5 V, T_A = 25°C, R_L = 10 kΩ (unless otherwise noted) (see Notes 3, 4, 5, and 6)

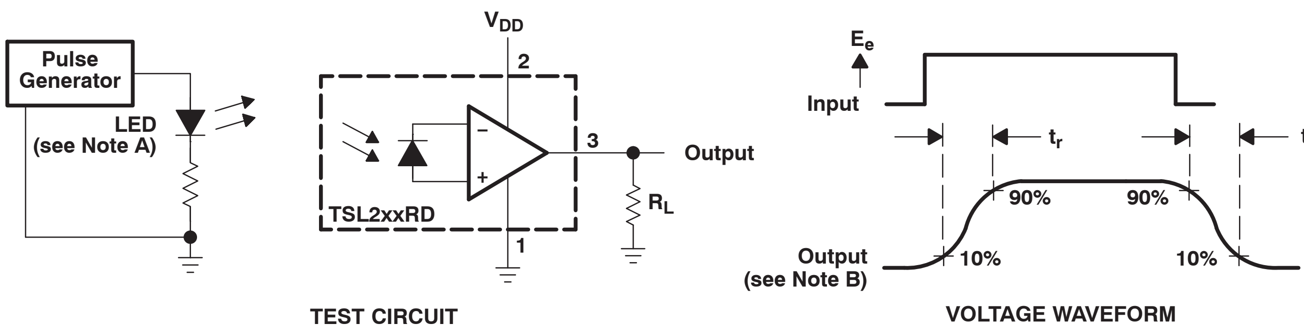
PARAMETER		TEST CONDITIONS	λp = 640 nm						λp = 940 nm						UNIT
			TSL250RD			TSL251RD			TSL260RD			TSL261RD			
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_D	Dark voltage	$E_e = 0$	0	5	10	0	5	10	0	5	10	0	5	10	mV
V_{OM}	Maximum output voltage	V_{DD} = 4.5 V	3	3.3		3	3.3		3	3.3		3	3.3		V
V_O	Output voltage	E_e = 31 μW/cm^2	1.5	2	2.5										V
		E_e = 124 μW/cm^2				1.5	2	2.5							
		E_e = 34 μW/cm^2							1	2	3				
		E_e = 132 μW/cm^2										1	2	3	
R_e	Irradiance responsivity	See Note 7		64			16			58			15		mV/ (μW/ cm^2)
Temperature coefficient of output voltage (V_O)		V_O = 2 V @ 25°C, T_A = 0°C to 70°C (see Note 8)		2			2			8			8		mV/°C
				0.1			0.1			0.4			0.4		%/°C
I_{DD}	Supply current	E_e = 31 μW/cm^2		1.1	1.7										mA
		E_e = 124 μW/cm^2					1.1	1.7							
		E_e = 34 μW/cm^2								1.1	1.7				
		E_e = 132 μW/cm^2											1.1	1.7	

NOTES: 4. Measurements are made with R_L = 10 kΩ between output and ground.
5. Optical measurements are made using small-angle incident radiation from an LED optical source.
6. The 640 nm input irradiance E_e is supplied by an AlInGaP LED with peak wavelength λ_p = 640 nm.
7. The 940 nm input irradiance E_e is supplied by a GaAs LED with peak wavelength λ_p = 940 nm.
8. Irradiance responsivity is characterized over the range V_O = V_D to 3 V. The best-fit straight line of Output Voltage V_O versus irradiance E_e over this range will typically have a positive extrapolated V_O value for E_e = 0.
9. The temperature coefficient of output voltage measurement is made by adjusting irradiance such that V_O is approximately 2 V at 25°C and then with irradiance held constant, measuring V_O while varying the temperature between 0°C and 70°C.

Dynamic Characteristics at V_{DD} = 5 V, T_A = 25°C, R_L = 10 kΩ (unless otherwise noted) (see Figure 1)

PARAMETER		TEST CONDITIONS	λp = 640 nm						λp = 940 nm						UNIT
			TSL250RD			TSL251RD			TSL260RD			TSL261RD			
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_r	Output pulse rise time	$V_{O(peak)}$ = 2 V		260			70			260			70		μs
t_f	Output pulse fall time	$V_{O(peak)}$ = 2 V		260			70			260			70		μs
V_n	Output noise voltage	E_e = 0, f = 1000 Hz		0.8			0.7			0.8			0.7		μV/ (√(Hz))

PARAMETER MEASUREMENT INFORMATION



NOTES: A. The input irradiance is supplied by a pulsed light-emitting diode with t_r < 1 μs, t_f < 1 μs.

B. The output waveform is monitored on an oscilloscope with the following characteristics: t_r < 100 ns, Z_i ≥ 1 MΩ, C_i ≤ 20 pF.

Figure 1. Switching Times

TYPICAL CHARACTERISTICS

OUTPUT VOLTAGE vs IRRADIANCE

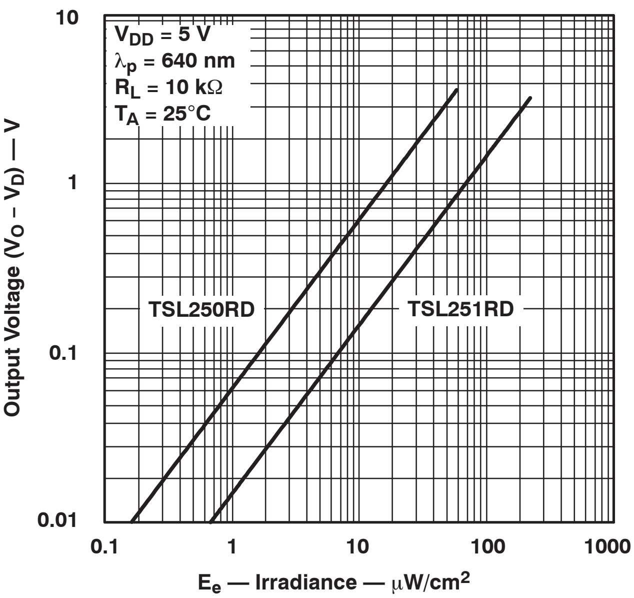


Figure 2

OUTPUT VOLTAGE vs IRRADIANCE

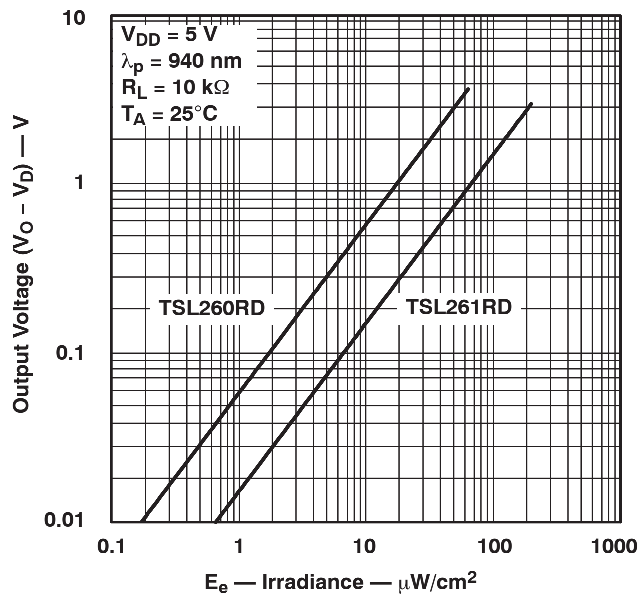


Figure 3

PHOTODIODE SPECTRAL RESPONSIVITY

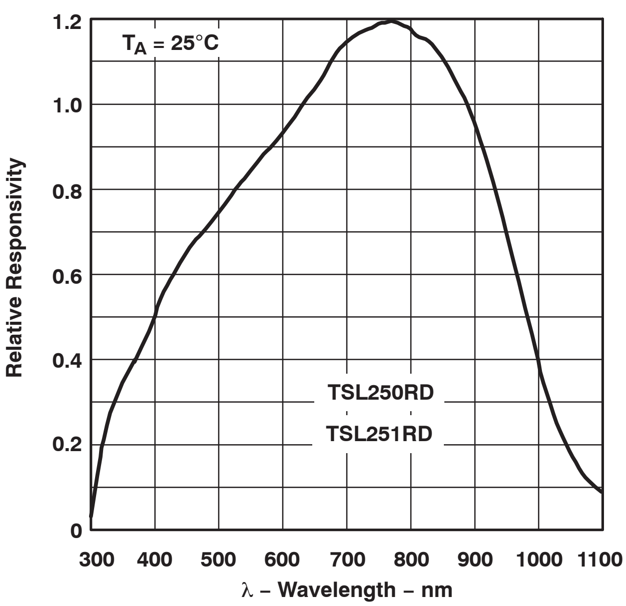


Figure 4

PHOTODIODE SPECTRAL RESPONSIVITY

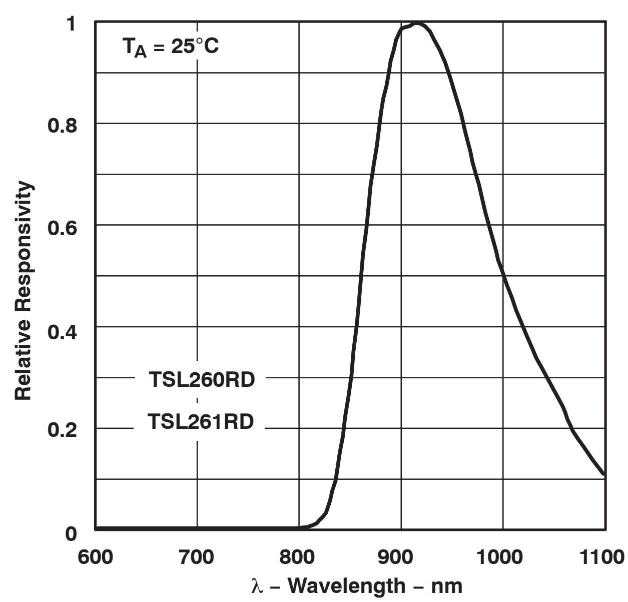


Figure 5

TYPICAL CHARACTERISTICS

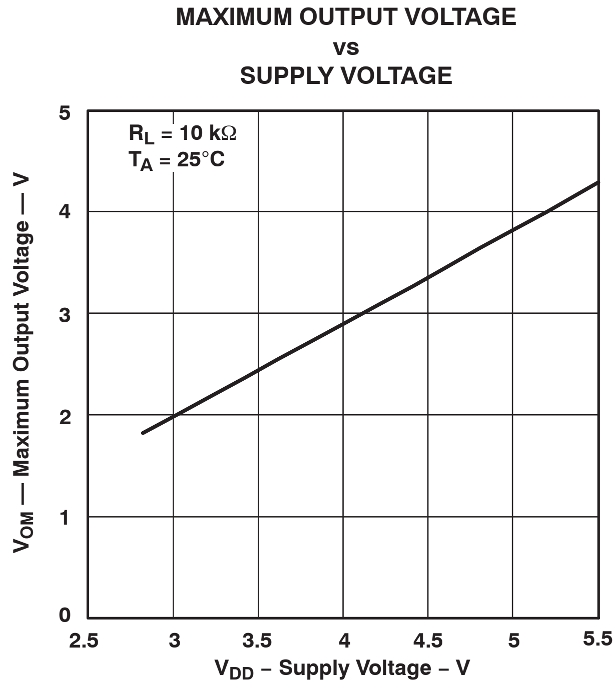


Figure 6

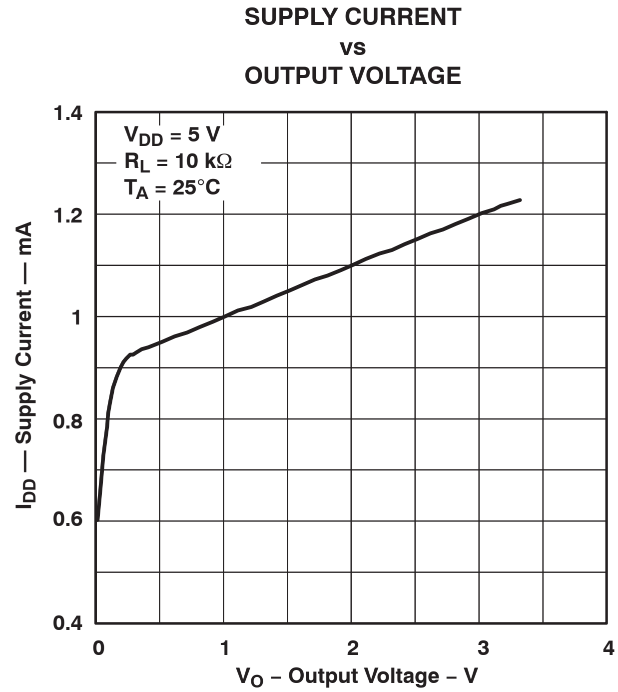


Figure 7

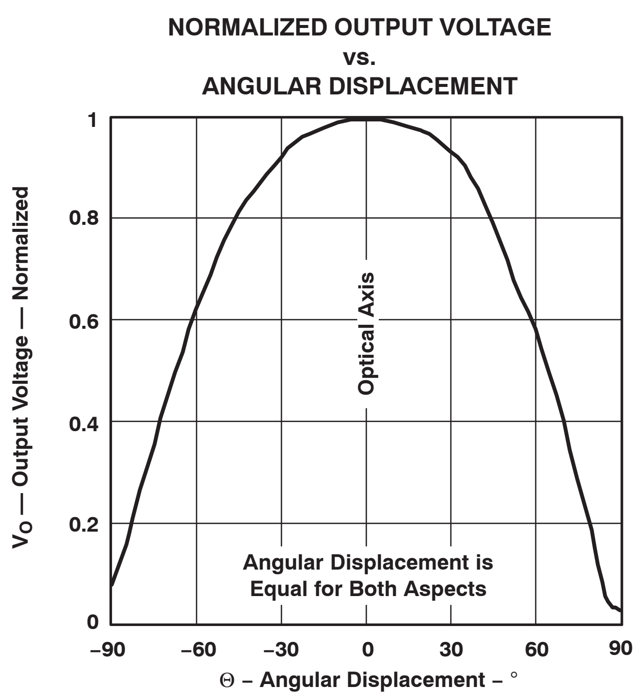


Figure 8

APPLICATION INFORMATION

Power Supply Considerations

For optimum device performance, power-supply lines should be decoupled by a 0.01-μF to 0.1-μF capacitor with short leads connected between VDD and GND mounted close to the device package.

Device Operational Details

The voltage developed at the output pin (OUT) is given by:

$$V_O = V_D + (R_e)\,(E_e)$$

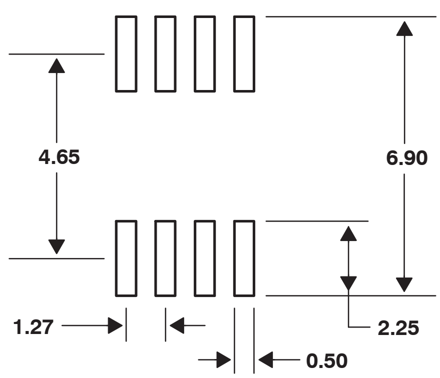
where:

V_O is the output voltage
V_D is the output voltage for dark condition ($E_e = 0$)
R_e is the device responsivity for a given wavelength of light given in mV/(μW/cm^2)
E_e is the incident irradiance in μW/cm^2

V_D is a fixed offset voltage resulting primarily from the input offset voltage of the internal op amp. As shown in the equation above, this voltage represents a constant, light-independent term in the total output voltage V_O. At low light levels, this offset voltage can be a significant percentage of V_O. For optimum performance of any given device over the full output range, the value of V_D should be measured (in the absence of light) and later subtracted from all subsequent light measurements (see Figures 2 and 3).

PCB Pad Layout

Suggested PCB pad layout guidelines for the D package is shown in Figure 9.



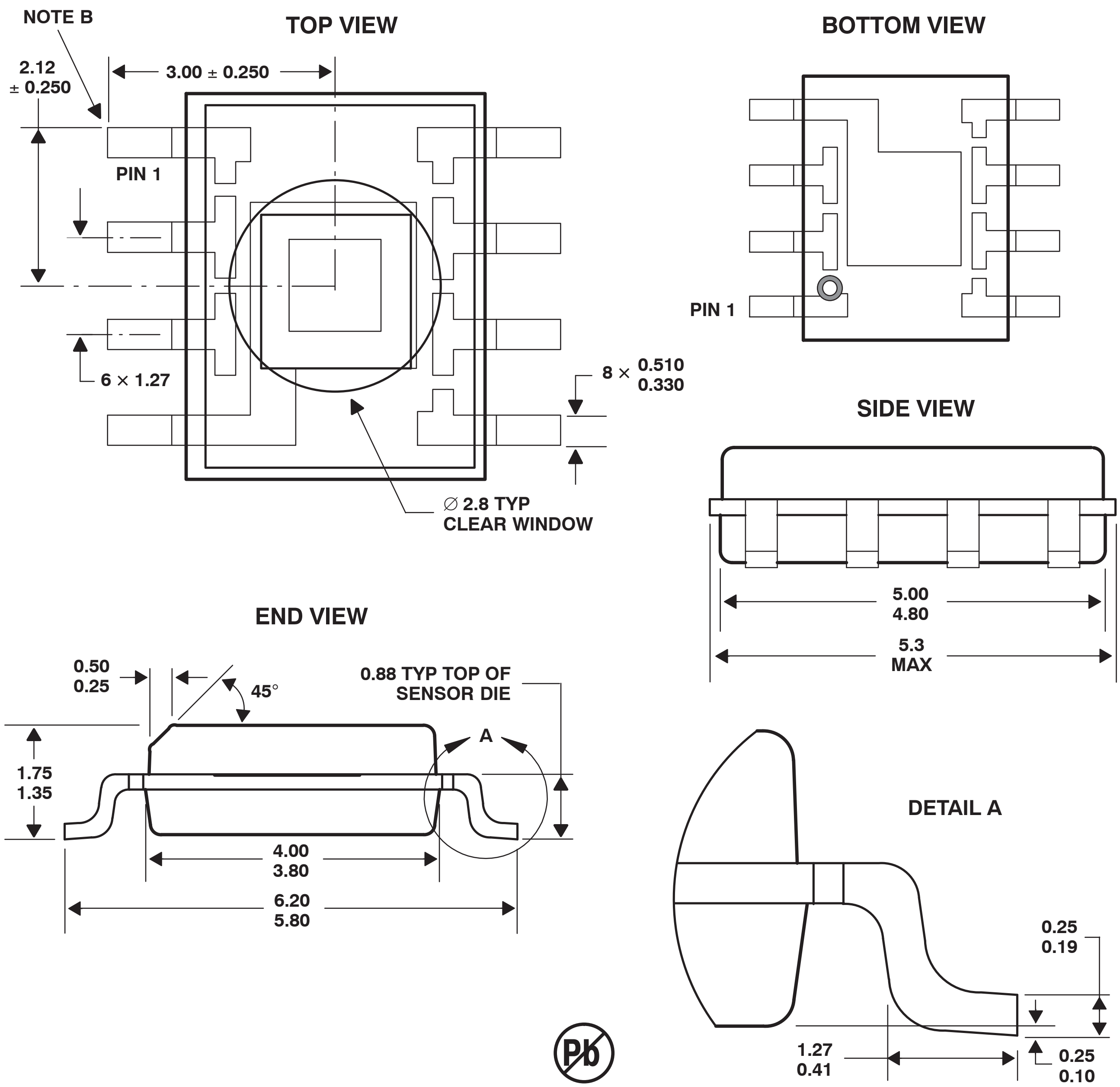
NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.

Figure 9. Suggested D Package PCB Layout

MECHANICAL DATA

This SOIC package consists of an integrated circuit mounted on a lead frame and encapsulated with an electrically nonconductive clear plastic compound. The photodiode area is typically 1.02 mm^2 for the TSL250RD and TSL260RD, and is typically 0.514 mm^2 for the TSL251RD and TSL261RD.

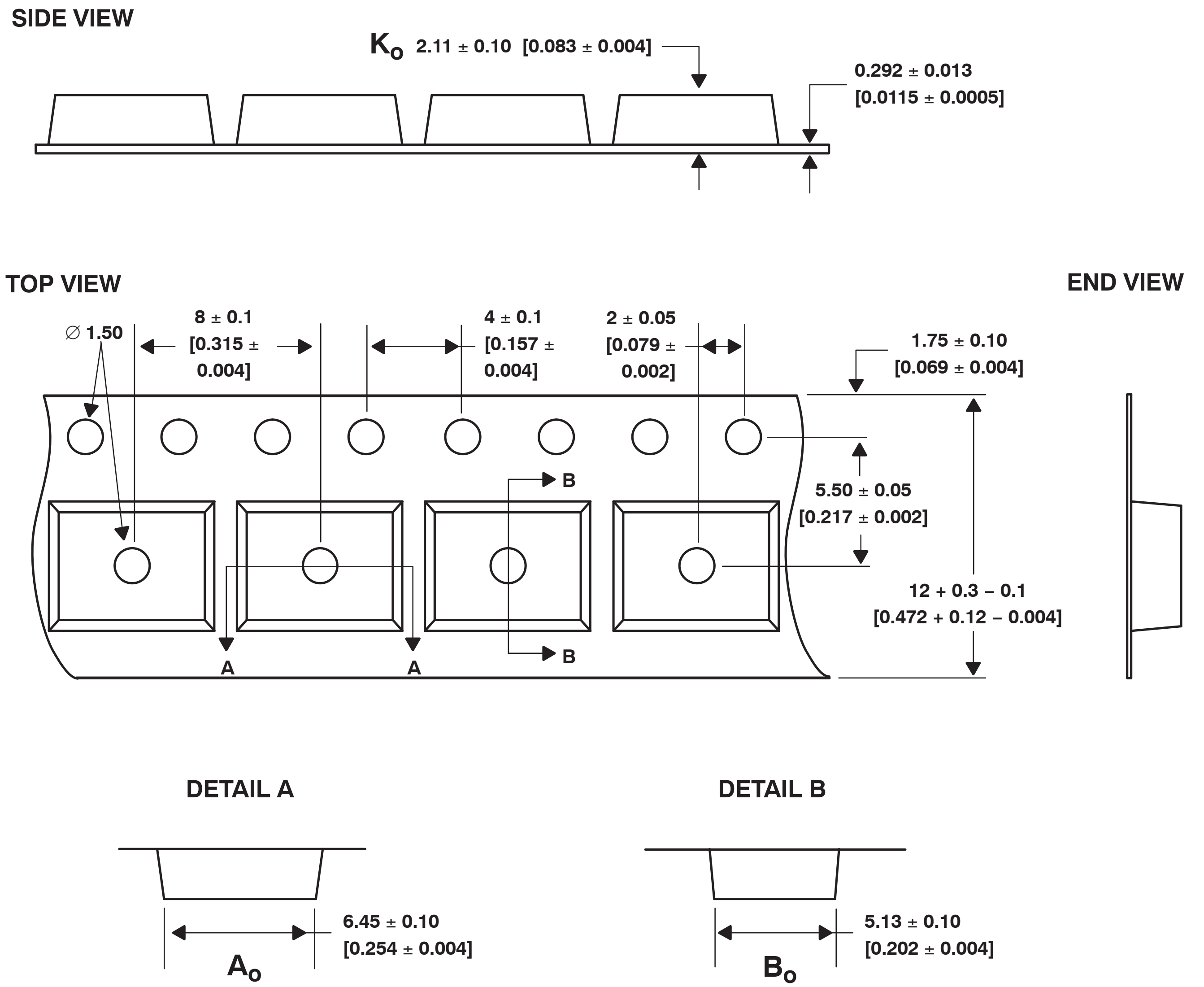
PACKAGE D **PLASTIC SMALL-OUTLINE**



NOTES: A. All linear dimensions are in millimeters.
B. The center of the photo-active area is referenced to the upper left corner tip of the lead frame (Pin 1).
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

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. This drawing is subject to change without notice.

Figure 11. Package D Carrier Tape

MANUFACTURING INFORMATION

The Plastic Small Outline IC package (D) has been tested and has demonstrated an ability to be reflow soldered to a PCB substrate.

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 component should be limited to a maximum of three passes through this solder reflow profile.

Table 1. TSL2xxRD Solder Reflow Profile

PARAMETER	REFERENCE	TSL2xxRD
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

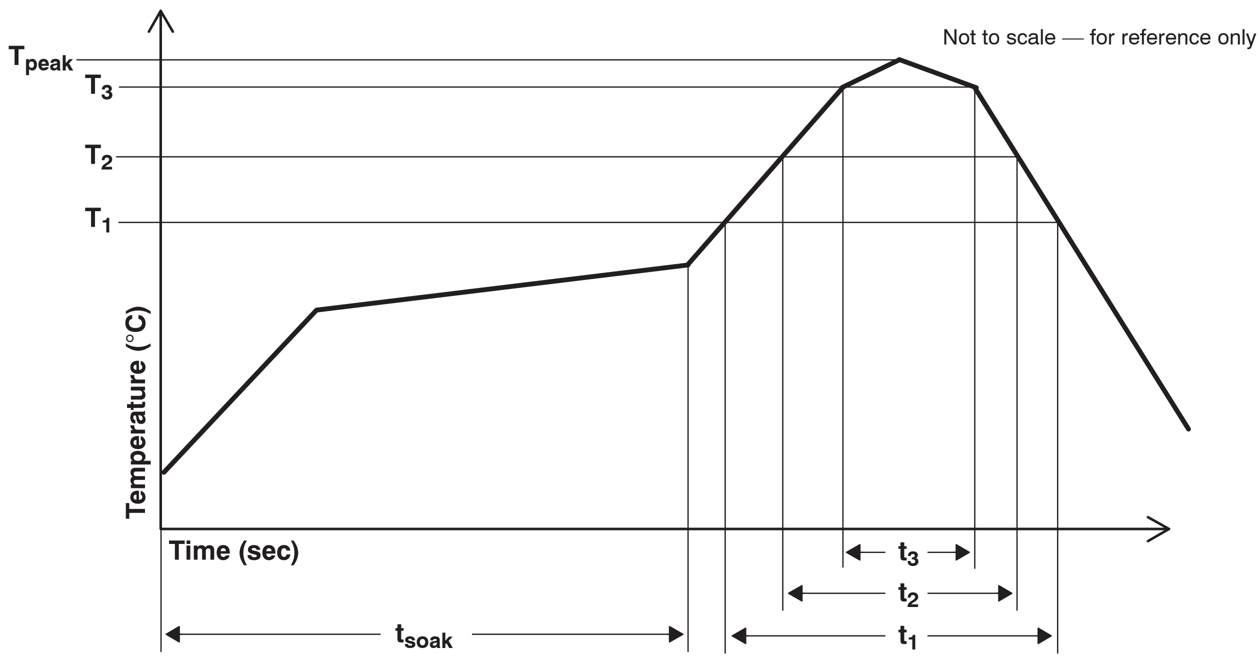


Figure 12. TSL2xxRD Solder Reflow Profile Graph

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. To prevent these adverse conditions, 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).

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