

# TSL250R, TSL251R, TSL252R

## Light-to-Voltage Optical Sensors

### General Description

The TSL250R, TSL251R, and TSL252R are light-to-voltage optical sensors, each combining a photodiode and a transimpedance amplifier (feedback resistor = 16M $\Omega$ , 8M $\Omega$ , and 2.8M $\Omega$  respectively) on a single monolithic IC. 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 and are supplied in a 3-lead clear plastic sidelooker package with an integral lens. When supplied in the lead (Pb) free package, the device is RoHS compliant.

*Ordering Information and Content Guide appear at end of datasheet.*

### Key Benefits & Features

The benefits and features of TSL250R, TSL251R, and TSL252R light-to-voltage optical sensors are listed below:

**Figure 1:**  
Added Value of Using TSL250R, TSL251R, and TSL252R

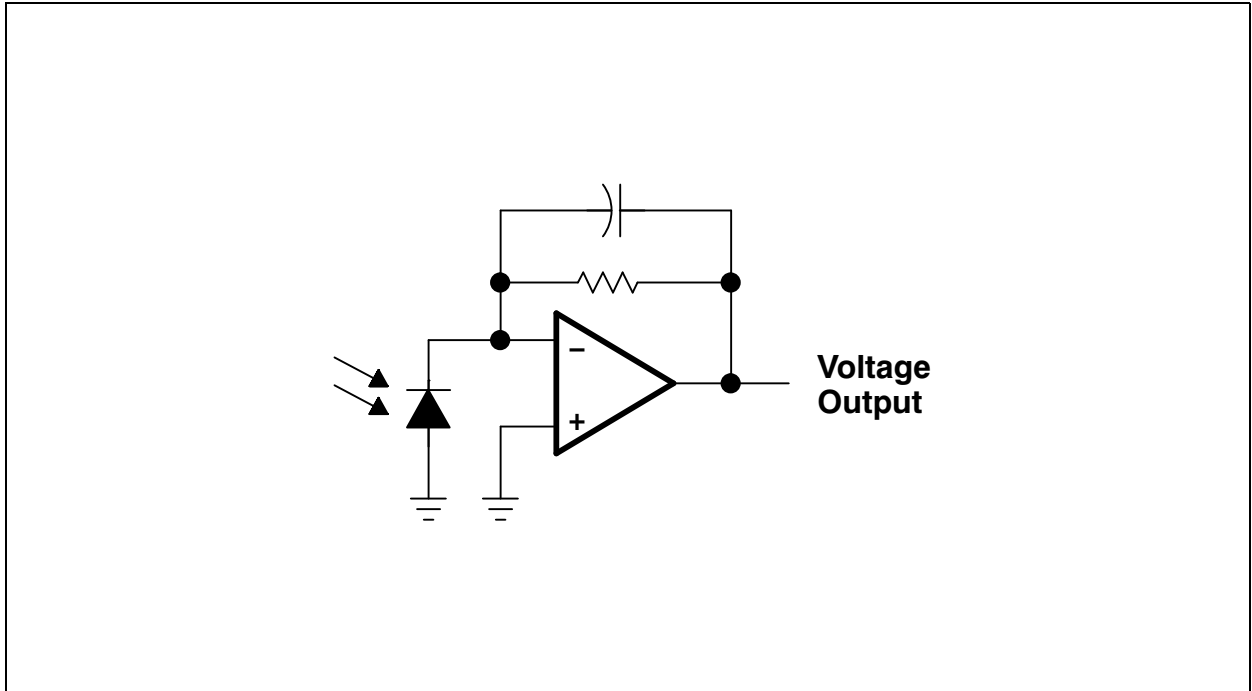
Benefits	Features
<ul style="list-style-type: none"> <li>Enables Extremely Fast Response to Change</li> </ul>	<ul style="list-style-type: none"> <li>Single Photo-Diode and Transimpedance Architecture</li> </ul>
<ul style="list-style-type: none"> <li>Enables Fast Response to Visible Light in Range of 400nm to 700nm Wavelengths</li> </ul>	<ul style="list-style-type: none"> <li>260<math>\mu</math>s Output Rise-Time Response (TSL250R)</li> </ul>
<ul style="list-style-type: none"> <li>Provides for High Sensitivity to Detect a Small Change in Light</li> </ul>	<ul style="list-style-type: none"> <li>High Irradiance Responsivity 137mV/(<math>\mu</math>W/cm<sup>2</sup>) @ <math>\lambda_p</math> = 635nm (TSL250R)</li> </ul>
<ul style="list-style-type: none"> <li>Provides Additional Sensitivity Advantages</li> </ul>	<ul style="list-style-type: none"> <li>2x Gain Lens</li> </ul>

- Monolithic silicon IC containing photodiode, operational amplifier, and feedback components
- Converts light intensity to a voltage
- Compact 3-lead clear plastic package
- Single voltage supply operation
- Low dark (offset) voltage... 10mV max
- Low supply current... 1.1mA typical
- Wide supply-voltage range... 2.7V to 5.5V
- Replacements for TSL250, TSL251, and TSL252
- RoHS compliant

## Functional Block Diagram

The functional blocks of this device are shown below:

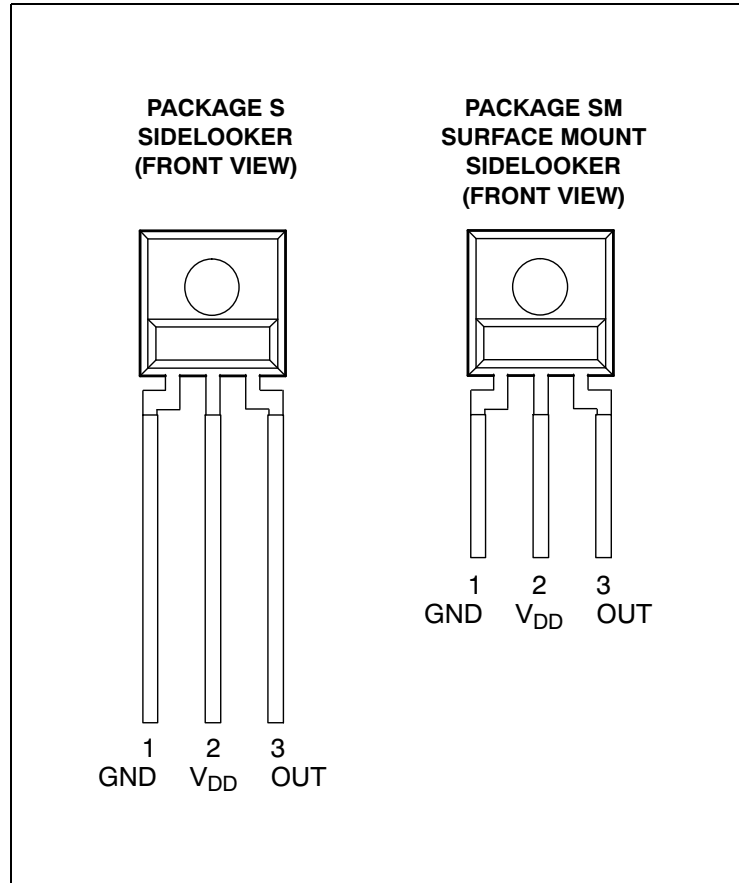
Figure 2:  
TSL250R, TSL251R, and TSL252R Block Diagram



## Pin Assignment

The TSL250R, TSL251R, and TSL252R pin assignments are described below.

**Figure 3:**  
Pin Diagram



**Figure 4:**  
Terminal Functions

Terminal		Description
No.	Name	
1	GND	Ground (substrate). All voltages are referenced to GND.
2	V <sub>DD</sub>	Supply voltage
3	OUT	Output voltage

## Absolute Maximum Ratings

Stresses beyond those listed under [Absolute Maximum Ratings](#) may cause permanent damage to the device. These are stress ratings only. 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 rating conditions for extended periods may affect device reliability.

**Figure 5:**  
**Absolute Maximum Ratings Over Operating Free-Air Temperature Range (unless otherwise noted)**

Symbol	Parameter	Min	Max	Unit
$V_{DD}$	Supply voltage <sup>(1)</sup>		6	V
$I_O$	Output current		±10	mA
	Duration of short-circuit current at (or below) 25°C <sup>(2)</sup>		5	s
$T_A$	Operating free-air temperature range	-25	85	°C
$T_{STRG}$	Storage temperature range	-25	85	°C
	Lead temperature 1.6mm (1/16 inch) from case for 10 seconds (S Package)		260	°C
	Reflow solder, in accordance with J-STD-020C or J-STD-020D (SM Package)		260	°C

**Note(s):**

1. All voltages are with respect to GND.
2. Output may be shorted to supply.

## Electrical Characteristics

All limits are guaranteed. The parameters with min and max values are guaranteed with production tests or SQC (Statistical Quality Control) methods.

**Figure 6:**  
**Recommended Operating Conditions**

Symbol	Parameter	Min	Nom	Max	Unit
$V_{DD}$	Supply voltage	2.7		5.5	V
$T_A$	Operating free-air temperature	0		70	°C

**Figure 7:**
**Electrical Characteristics at  $V_{DD} = 5V$ ,  $T_A = 25^\circ C$ ,  $\lambda_p = 635nm$ ,  $R_L = 10k\Omega$  (unless otherwise noted) <sup>(1), (2), (3)</sup>**

Symbol	Parameter	Test Conditions	TSL250R			TSL251R		
			Min	Typ	Max	Min	Typ	Max
$V_D$	Dark voltage	$E_e = 0$	0	4	10	0	4	10
$V_{OM}$	Maximum output voltage	$V_{DD} = 4.5V$	3.0	3.3		3.0	3.3	
$V_O$	Output voltage	$E_e = 14.6\mu W/cm^2$	1.5	2	2.5			
		$E_e = 38.5\mu W/cm^2$				1.5	2	2.5
		$E_e = 196\mu W/cm^2$						
$\alpha_{VO}$	Temperature coefficient of output voltage ( $V_O$ )	$E_e = 14.6\mu W/cm^2$		1.6				
		$T_A = 0^\circ C$ to $70^\circ C$		0.08				
		$E_e = 38.5\mu W/cm^2$					1.6	
		$T_A = 0^\circ C$ to $70^\circ C$					0.08	
		$E_e = 196\mu W/cm^2$						
		$T_A = 0^\circ C$ to $70^\circ C$						
$N_e$	Irradiance responsivity	$\lambda_p = 635\text{ nm}$ <sup>(3), (5)</sup>		137			52	
		$\lambda_p = 880\text{ nm}$ <sup>(4), (5)</sup>		127			48	

TSL250R, TSL251R, TSL252R – Electrical Characteristics

Symbol	Parameter	Test Conditions	TSL250R			TSL251R		
			Min	Typ	Max	Min	Typ	Max
$I_{DD}$	Supply current	$E_e = 14.6\mu\text{W}/\text{cm}^2$		1.1	1.7			
		$E_e = 38.5\mu\text{W}/\text{cm}^2$					1.1	1.7
		$E_e = 196\mu\text{W}/\text{cm}^2$						

**Note(s):**

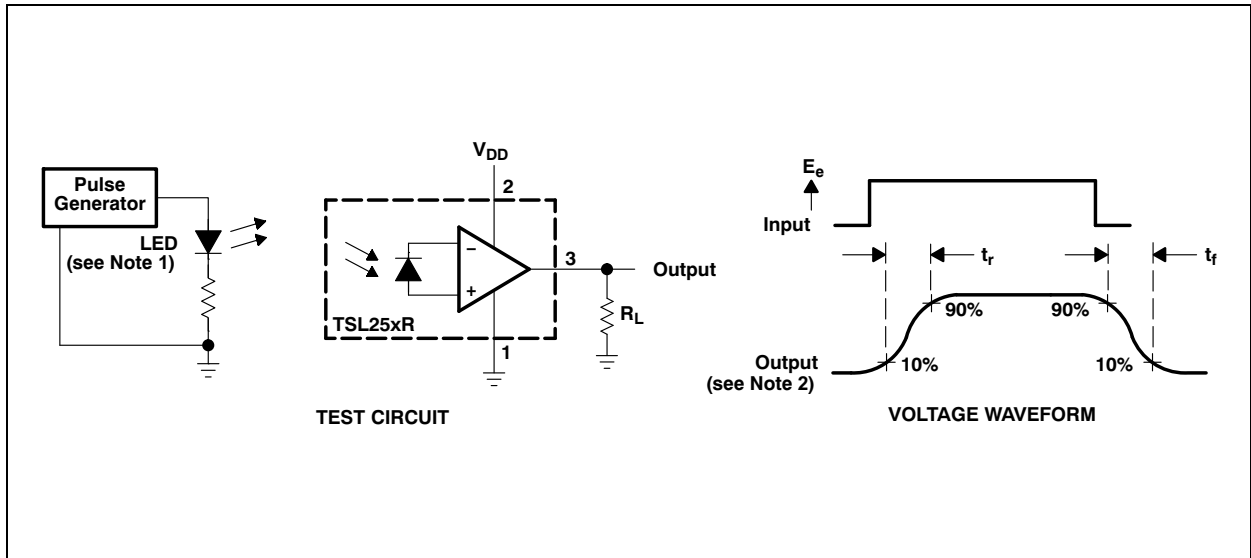
1. Measurements are made with  $R_L = 10\text{k}\Omega$  between output and ground.
2. Optical measurements are made using small-angle incident radiation from an LED optical source.
3. The input irradiance  $E_e$  is supplied by an AlInGaP LED with peak wavelength  $\lambda_p = 635\text{nm}$ .
4. The input irradiance  $E_e$  is supplied by an GaAlAs LED with peak wavelength  $\lambda_p = 880\text{nm}$ .
5. Irradiance responsivity is characterized over the range  $V_O = 0.05$  to  $2.9\text{V}$ . The best-fit straight line of Output Voltage  $V_O$  versus irradiance  $E_e$  over the  $V_O$  value for  $E_e = 0$ .

**Figure 8:**  
Dynamic Characteristics at  $T_A = 25^\circ\text{C}$  (see Figure 9)

Symbol	Parameter	Test Conditions	TSL250R			TSL251R		
			Min	Typ	Max	Min	Typ	Max
$t_r$	Output pulse rise time	$V_{DD} = 5\text{V}, \lambda_p = 635\text{nm}$		260			70	
$t_f$	Output pulse fall time	$V_{DD} = 5\text{V}, \lambda_p = 635\text{nm}$		260			70	
$V_n$	Output noise voltage	$V_{DD} = 5\text{V}, E_e = 0, f = 1000\text{Hz}$		0.8			0.7	

## Parameter Measurement Information

Figure 9:  
Switching Times



**Note(s):**

1. The input irradiance is supplied by a pulsed AlInGaP light-emitting diode with the following characteristics:  $\lambda_p = 635\text{nm}$ ,  $t_r < 1\mu\text{s}$ ,  $t_f < 1\mu\text{s}$ .
2. The output waveform is monitored on an oscilloscope with the following characteristics:  $t_r < 100\text{ns}$ ,  $Z_i \geq 1\text{M}\Omega$ ,  $C_i \leq 20\text{pF}$ .



## Typical Characteristics

Figure 10:  
Normalized Output Voltage vs. Angular Displacement

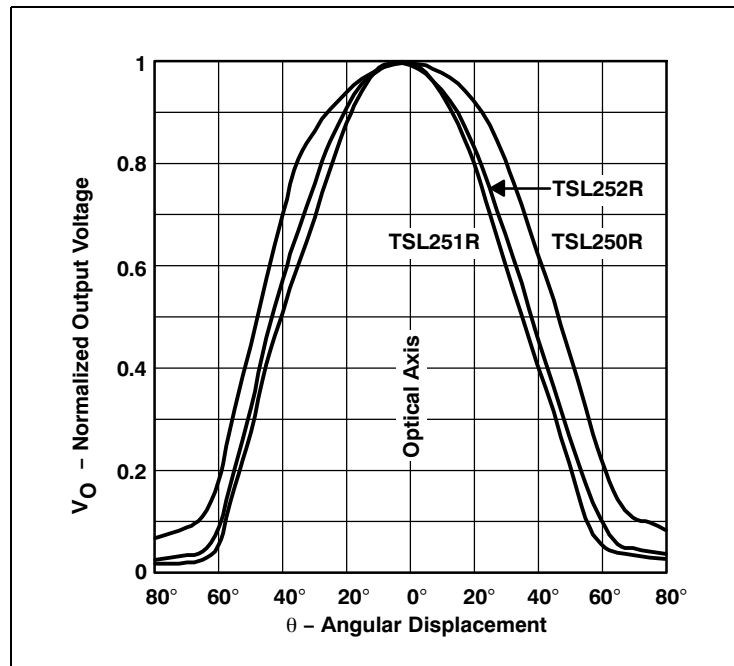


Figure 11:  
Output Voltage vs. Irradiance

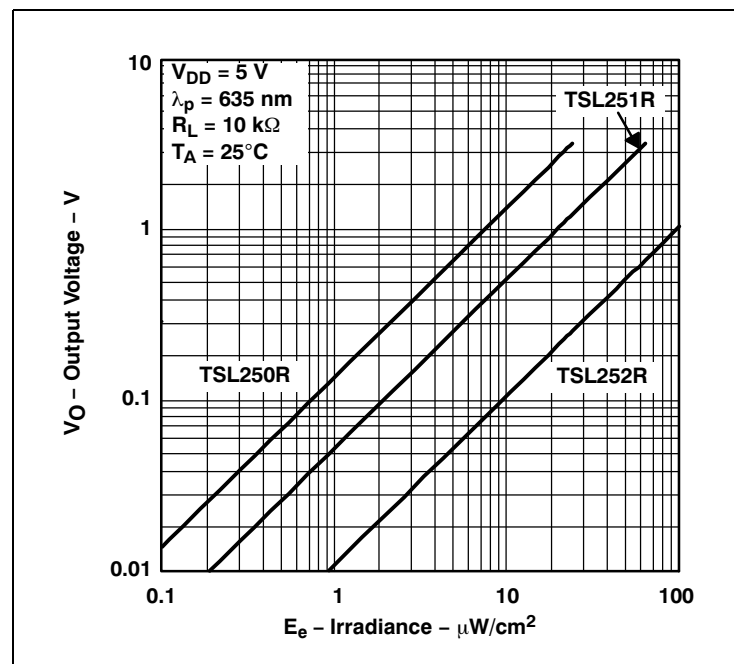


Figure 12:  
Photodiode Spectral Responsivity

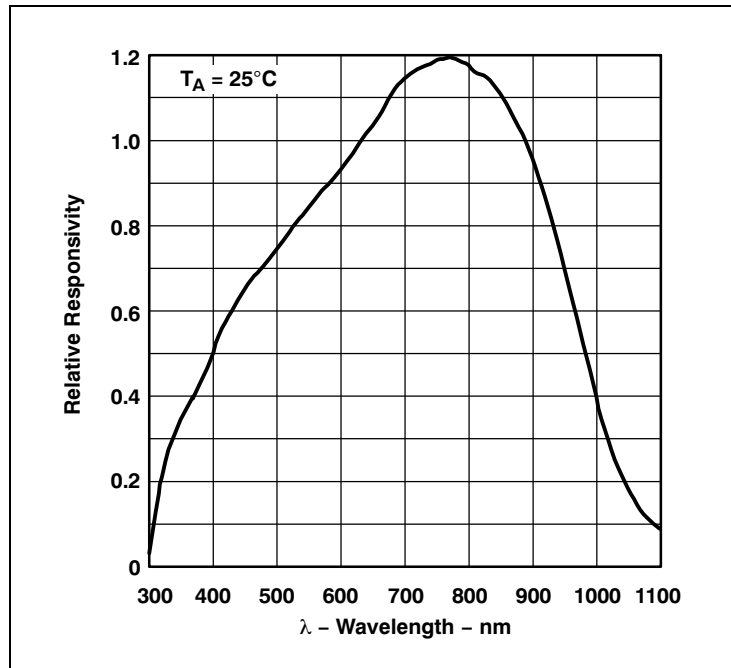
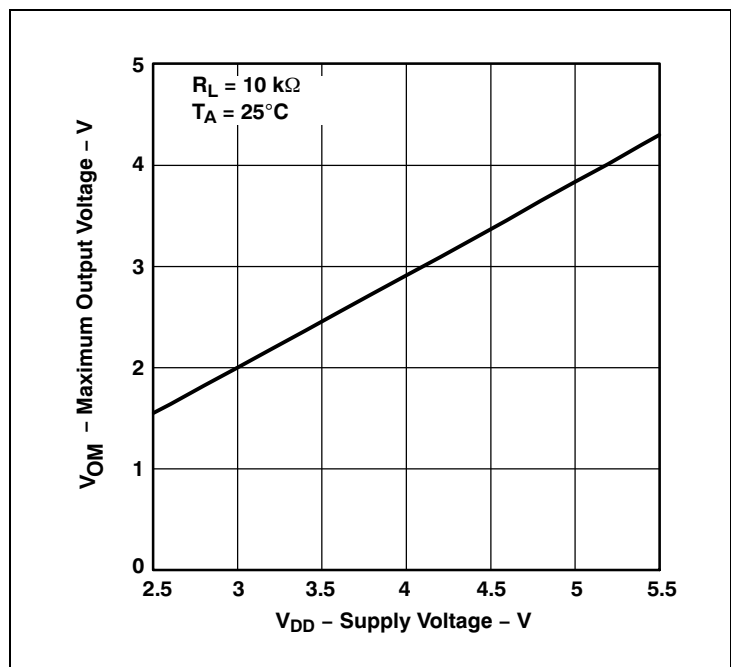
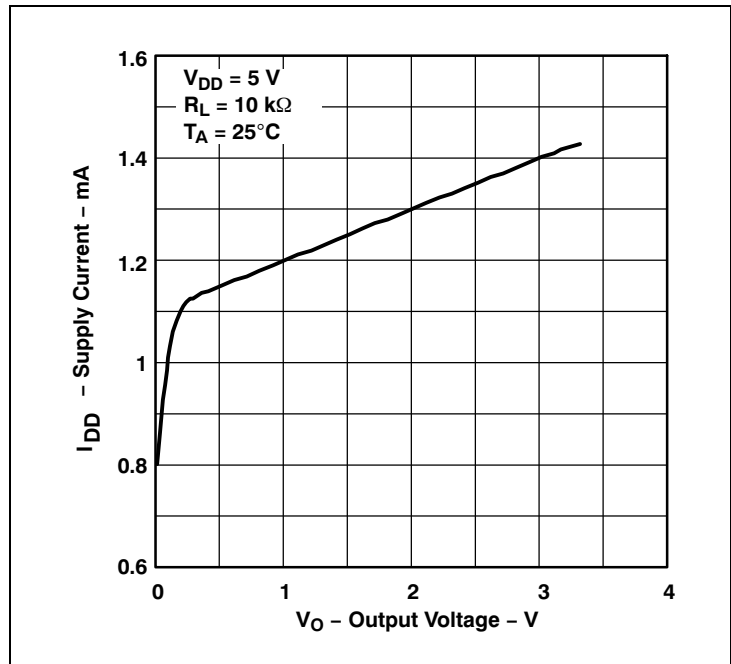


Figure 13:  
Maximum Output Voltage vs. Supply Voltage



**Figure 14:**  
Supply Current vs. Output Voltage

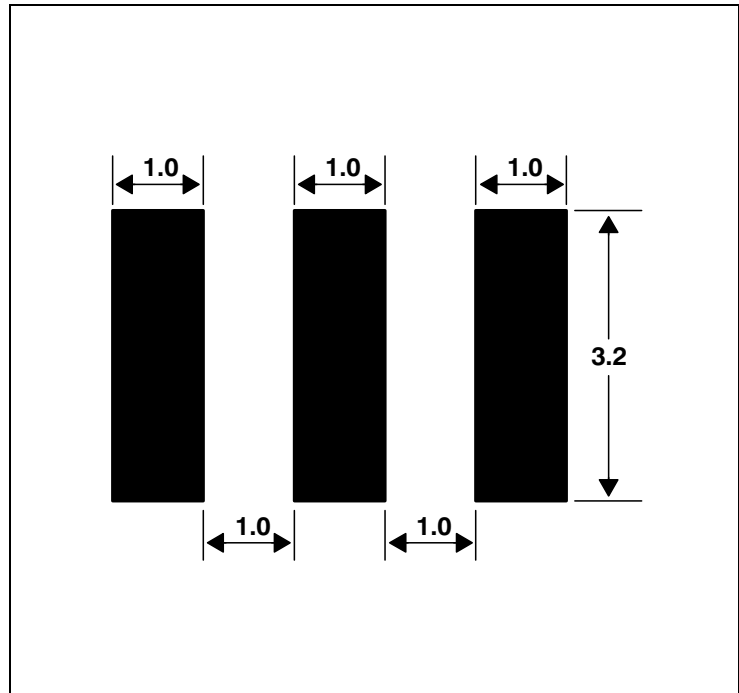


## Application Information

### PCB Pad Layout

Suggested PCB pad layout guidelines for the SM surface mount package are shown in [Figure 15](#).

**Figure 15:**  
**Suggested SM Package PCB Layout**



**Note(s):**

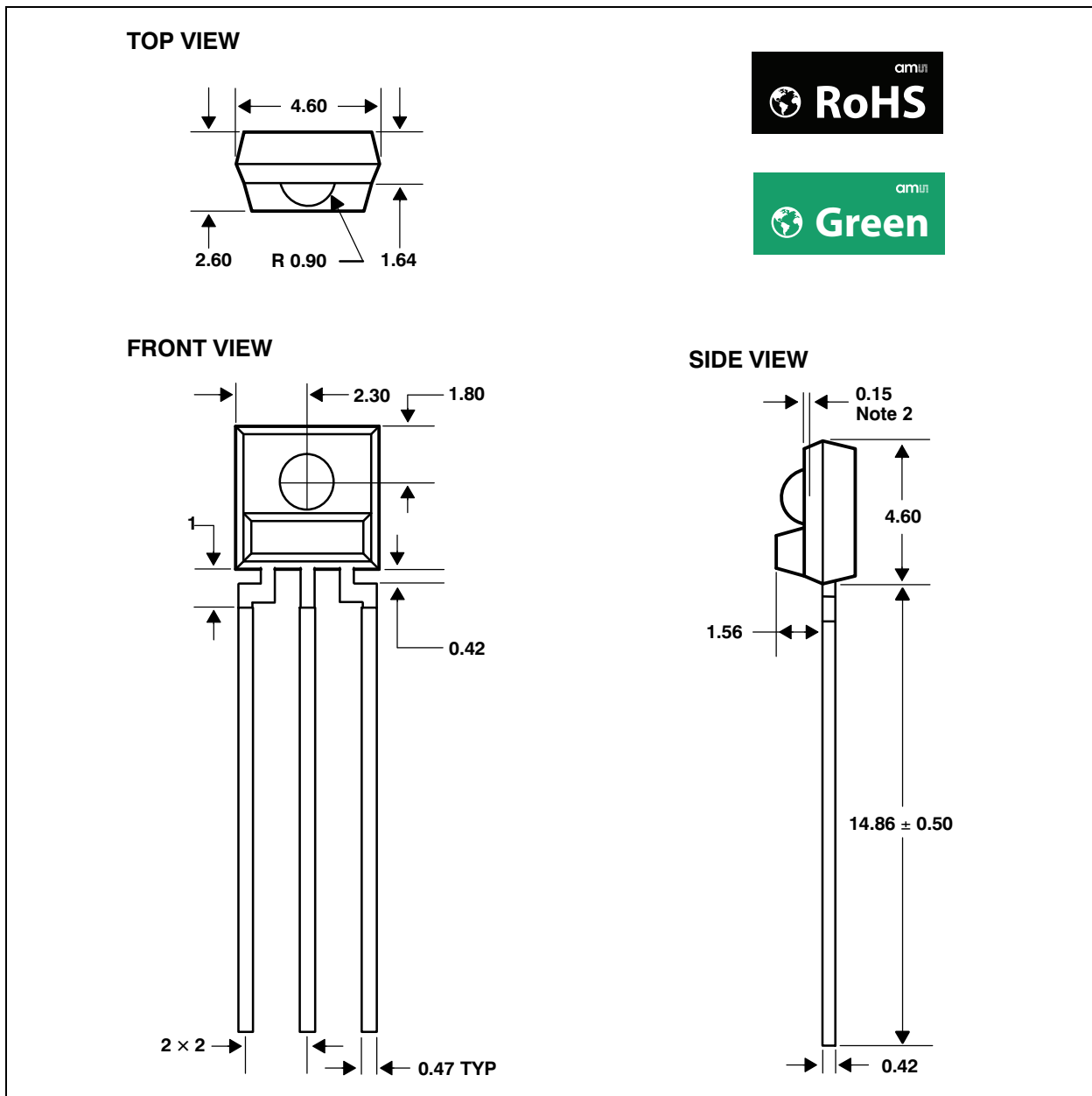
1. All linear dimensions are in millimeters.
2. This drawing is subject to change without notice.

## Mechanical Information

The devices are supplied in a clear plastic three-lead package (S). The integrated photodiode active area is typically  $1.0\text{mm}^2$  ( $0.0016\text{in}^2$ ) for TSL250R,  $0.5\text{mm}^2$  ( $0.00078\text{in}^2$ ) for the TSL251R, and  $0.26\text{mm}^2$  ( $0.0004\text{in}^2$ ) for the TSL252R.

### Plastic Single-In-Line Side-Looker Package

**Figure 16:**  
Plastic Single-In-Line Side-Looker Package Configuration

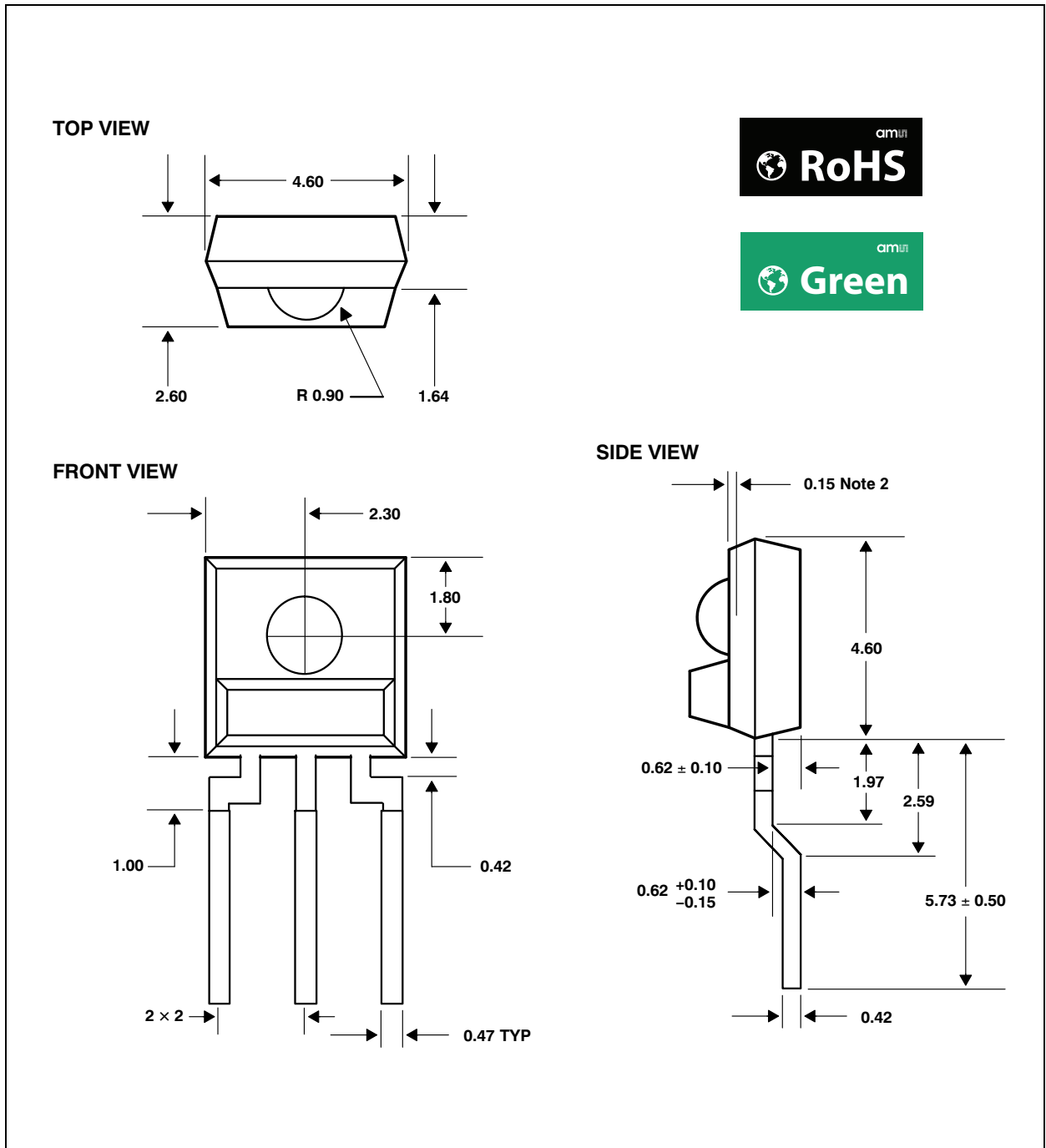


#### Note(s):

1. All linear dimensions are in millimeters; tolerance is  $\pm 0.25\text{mm}$  unless otherwise stated.
2. Dimension is to center of lens arc, which is located below the package face.
3. The integrated photodiode active area is typically located in the center of the lens and  $0.97\text{mm}$  below the top of the lens surface.
4. Index of refraction of clear plastic is 1.55.
5. Lead finish for TSL25xR-LF: solder dipped, 100% Sn.
6. This drawing is subject to change without notice.

### Plastic Surface Mount Side-Looker Package

Figure 17:  
Package SM - Plastic Surface Mount Side-Looker Package Configuration



**Note(s):**

1. All linear dimensions are in millimeters; tolerance is  $\pm 0.25$ mm unless otherwise stated.
2. Dimension is to center of lens arc, which is located below the package face.
3. The integrated photodiode active area is typically located in the center of the lens and 0.97mm below the top of the lens surface.
4. Index of refraction of clear plastic is 1.55.
5. Lead finish for TSL25xRSM-LF: solder dipped, 100% Sn.
6. This drawing is subject to change without notice.

## Ordering & Contact Information

Figure 18:  
Ordering Information

Ordering Code	Device	T <sub>A</sub>	Package-Leads	Package Designator
TSL250R-LF	TSL250R	0°C to 70°C	3-lead Sidelooker - Lead (Pb) Free	S
TSL250RSM-LF	TSL250R	0°C to 70°C	3-lead Surface-Mount Sidelooker - Lead (Pb) Free	SM
TSL251R-LF	TSL251R	0°C to 70°C	3-lead Sidelooker - Lead (Pb) Free	S
TSL251RSM-LF	TSL251R	0°C to 70°C	3-lead Surface-Mount Sidelooker - Lead (Pb) Free	SM
TSL252R-LF	TSL252R	0°C to 70°C	3-lead Sidelooker - Lead (Pb) Free	S
TSL252RSM-LF	TSL252R	0°C to 70°C	3-lead Surface-Mount Sidelooker - Lead (Pb) Free	SM

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## Revision Information

Changes from 028H (2007-Sep) to current revision 1-00 (2016-May-30)	Page
Content of TAOS datasheet was converted to the latest <b>ams</b> design	
Updated Key Benefits & Features	1
Updated notes under Figure 16	13
Updated Figure 18	15

**Note(s):**

1. Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
2. Correction of typographical errors is not explicitly mentioned.

## Content Guide

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1	Key Benefits & Features
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<b>3</b>	<b>Pin Assignment</b>
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