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# TSL250RD, TSL251RD, TSL260RD, TSL261RD Light-to-Voltage Optical Sensors

## **General 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 M $\Omega$  and a photodiode measuring 1 square mm. The TSL251RD and TSL261RD have an equivalent feedback resistance of 8 M $\Omega$  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.

Ordering Information and Content Guide appear at end of datasheet.

## **Key Benefits & Features**

The benefits and features of TSL250RD, TSL251RD, TSL260RD, and TSL261RD Light-to-Voltage Optical Sensors, are listed below:

Figure 1: Added Value of Using TSL250RD / TSL251RD / TSL260RD / TSL261RD

Benefits	Features
Enables Extremely Fast Response to Change	Single Photo-Diode and Transimpedance Architecture
• Enables Fast Response to Visible Light in Range of 400nm to 700nm Wavelengths	<ul> <li>Output Rise-Time Response, Typically</li> <li>260μs (TSL250RD, TSL260RD)</li> <li>70μs (TSL251RD, TSL261RD)</li> </ul>
<ul> <li>Provides for High Sensitivity to Detect a Small Change in Light</li> </ul>	<ul> <li>High Irradiance Responsivity, Typically</li> <li>64mV/(μW/cm<sup>2</sup>) @ λp = 640nm (TSL250RD)</li> <li>58mV/(μW/cm<sup>2</sup>) @ λp = 940nm (TSL260RD)</li> </ul>
Reduces Board Space Requirements     while Simplifying Designs	• 5mm x 6.2mm SOIC (D) Package

- Monolithic Silicon IC Containing Photodiode, Operational Amplifier, and Feedback Components
- Converts Light Intensity to a Voltage
- 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)
- 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

## **Functional Block Diagram**

The functional blocks of this device are shown below:

Figure 2: TSL250RD, TSL251RD, TSL260RD, and TSL261RD





# **Pin Assignments**

The TSL250RD, TSL251RD, TSL260RD, and TSL261RD pin assignments are described below:

Figure 3: Pin Diagram of Package D 8-Lead SOIC (Top View)



Figure 4: Terminal Functions

Term	inal	Description
Name	No.	Description
GND	4	Ground (substrate) All voltages are referenced to GND.
V <sub>DD</sub>	6	Supply voltage
OUT	7	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	Мах	Unit
V <sub>DD</sub>	Supply voltage <sup>(1)</sup>		6	V
۱ <sub>0</sub>	Output Current		±10	mA
	Duration of short-circuit current at (or below) $25^{\circ}C^{(2)}$		5	S
T <sub>A</sub>	Operating free-air temperature range	-25	85	°C
T <sub>STRG</sub>	Storage temperature range	-25	85	°C
	Solder conditions in accordance with JEDEC J-STD-020A, maximum temperature <sup>(3)</sup>		260	°C

#### Note(s):

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.



## **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	Мах	Unit
V <sub>DD</sub>	Supply voltage	2.7		5.5	V
T <sub>A</sub>	Operating free-air temperature	0		70	°C

Figure 7:

Electrical Characteristics,  $V_{DD}$  = 5V,  $T_A$  = 25°C,  $R_L$ =10k $\Omega$  (unless otherwise noted) <sup>(1) (2) (3) (4)</sup>

			λ <sub>p</sub> = 640nm						λ <sub>p</sub> = 940nm						
Symbol	Parameter	Test Conditions	T	SL250F	RD	T	SL251F	RD	T	SL260F	RD	T	SL261F	RD	Unit
			Min	Тур	Max	Min	Тур	Мах	Min	Тур	Max	Min	Тур	Max	
V <sub>D</sub>	Dark voltage	$E_e = 0$	0	5	10	0	5	10	0	5	10	0	5	10	mV
V <sub>OM</sub>	Maximum output voltage	$V_{DD} = 4.5V$	3	3.3		3	3.3		3	3.3		3	3.3		V
		$E_e = 31 \mu\text{W/cm}^2$	1.5	2	2.5										
Vo		$E_{e} = 124 \ \mu W/'$				1.5	2	2.5							V
٧٥	output voltage	$E_e = 34 \mu\text{W/cm}^2$							1	2	3				]
		$E_e = 132 \mu\text{W/cm}^2$										1	2	3	

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			λ <sub>p</sub> = 640nm						λ <sub>p</sub> = 940nm						
Symbol	Parameter	rameter Test Conditions	TSL250RD			TSL251RD			TSL260RD			TSL261RD			Unit
			Min	Тур	Max	Min	Тур	Мах	Min	Тур	Max	Min	Тур	Max	
R <sub>e</sub>	Irradiance responsivity	See note (4)		64			16			58			15		mV/ (µW/cm <sup>2</sup> )
	Temperature	$V_{0} = 2V @ 25^{\circ}C$		2			2			8			8		mV/°C
output voltage (V <sub>O</sub> )	output voltage (V <sub>O</sub> )	$T_{\rm A} = 0^{\circ} {\rm C} \text{ to } 70^{\circ} {\rm C}, $ <sup>(5)</sup>		0.1			0.1			0.4			0.4		%/°C
		$E_e = 31 \mu\text{W/cm}^2$		1.1	1.7										
I <sub>DD</sub>	Supply surront	$E_e = 124 \mu\text{W/cm}^2$					1.1	1.7							m 4
	Supply current	$E_e = 34 \mu\text{W/cm}^2$								1.1	1.7				
		$E_e = 132 \mu\text{W/cm}^2$											1.1	1.7	

#### Note(s):

- 1. Measurements are made with  $R_L = 10k\Omega$  between output and ground.
- 2. Optical measurements are made using small-angle incident radiation from an LED optical source.
- 3. The 640nm input irradiance  $E_e$  is supplied by an AlInGaP LED with peak wavelength  $\lambda_p$  = 640nm.
- 4. The 940nm input irradiance  $E_e$  is supplied by a GaAs LED with peak wavelength  $\lambda_p$  = 940nm.
- 5. Irradiance responsivity is characterized over the range V<sub>O</sub> = V<sub>D</sub> to 3V. The best-fit straight line of Output Voltage V<sub>O</sub> versus irradiance E<sub>e</sub> over this range will typically have a positive extrapolated V<sub>O</sub> value for E<sub>e</sub> = 0.
- 6. The temperature coefficient of output voltage measurement is made by adjusting irradiance such that V<sub>O</sub> is approximately 2V at 25°C and then with irradiance held constant, measuring V<sub>O</sub> while varying the temperature between 0°C and 70°C.

Figure 8:

Dynamic Characteristics,  $V_{DD} = 5V$ ,  $T_A = 25^{\circ}C$ ,  $R_L = 10k\Omega$  (unless otherwise noted) (see Figure 9)

		λ <sub>p</sub> = 640nm						λ <sub>p</sub> = 940nm							
Symbol Paramete		Test Conditions	T	TSL250R		RD T		SL251RD		TSL260RD		TSL261RD			Unit
			Min	Тур	Max	Min	Тур	Мах	Min	Тур	Max	Min	Тур	Max	
t <sub>r</sub>	Output pulse rise time	$V_{O(peak)} = 2V$		260			70			260			70		μs
t <sub>r</sub>	Output pulse fall time	$V_{O(peak)} = 2V$		260			70			260			70		μs
V <sub>n</sub>	Output noise voltage	$E_e = 0$ f = 1000Hz		0.8			0.7			0.8			0.7		$\frac{\mu V}{\sqrt{(Hz)}}$



# Parameter Measurement Information

Figure 9: Switching Times



#### Note(s):

1. The input irradiance is supplied by a pulsed light-emitting diode with  $t_r < 1\mu s$ ,  $t_f < 1\mu s$ .

2. The output waveform is monitored on an oscilloscope with the following characteristics:  $t_r < 100$ ns,  $Z_i \ge 1M\Omega$ ,  $C_i \le 20$  pF.



# **Typical Characteristics**



Figure 10: Output Voltage vs. Irradiance (TSL250RD, TSL251RD)

















Figure 14: Maximum Output Voltage vs. Supply Voltage



Figure 15: Supply Current vs. Output Voltage





### Figure 16: Normalized Output Voltage vs. Angular Displacement



## **Application Information**

## **Power Supply Considerations**

For optimum device performance, power-supply lines should be decoupled by a  $0.01\mu$ F to  $0.1\mu$ F capacitor with short leads connected between V<sub>DD</sub> and GND mounted close to the device package.

## **Device Operational Details**

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

(EQ1) 
$$V_0 = V_D + (R_e) (E_e)$$

where:

- V<sub>O</sub> 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/( $\mu$ W/cm^2)
- +  $E_e$  is the incident irradiance in  $\mu W/cm^2$

 $V_D$  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 Figure 10 and Figure 11).



## **PCB Pad Layout**

Suggested PCB pad layout guidelines for the D package is shown in Figure 17.

Figure 17: Suggested D Package PCB Layout



#### Note(s):

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



### Packaging 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 1.02mm<sup>2</sup> for the TSL250RD and TSL260RD, and is typically 0.514mm<sup>2</sup> for the TSL251RD and TSL261RD.

Figure 18:

Package D - Plastic Small-Outline IC Packaging Configuration



#### Note(s):

- 1. All linear dimensions are in millimeters.
- 2. The center of the photo-active area is referenced to the upper left corner tip of the lead frame (Pin 1).
- 3. Package is molded with an electrically nonconductive clear plastic compound having an index of refraction of 1.55.

4. This drawing is subject to change without notice.



Figure 19: Package D Carrier Tape



#### Note(s):

- 1. All linear dimensions are in millimeters [inches].
- 2. The dimensions on this drawing are for illustrative purposes only. Dimensions of an actual carrier may vary slightly.
- 3. Symbols on drawing  $A_{o}$ ,  $B_{o}$ , and  $K_{o}$  are defined in ANSI EIA Standard 481-B 2001.
- 4. Each reel is 178 millimeters in diameter and contains 1000 parts.
- 5. ams packaging tape and reel conform to the requirements of EIA Standard 481-B.
- 6. This drawing is subject to change without notice.



# 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.

Figure 20: TSL2xxRD Solder Reflow Profile

Parameter	Reference	TSL2xxRD
Average temperature gradient in preheating		2.5°C/s
Soak time	t <sub>soak</sub>	2 to 3 minutes
Time above 217°C	t <sub>1</sub>	Max 60 s
Time above 230°C	t <sub>2</sub>	Max 50 s
Time above T <sub>peak</sub> - 10°C	t <sub>3</sub>	Max 10 s
Peak temperature in reflow	T <sub>peak</sub>	260°C
Temperature gradient in cooling		Max -5°C/s

#### Figure 21:

TSL2xxRD Solder Reflow Profile Graph



#### Note(s):

1. Not to scale - for reference only.

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## **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).

# **Ordering & Contact Information**

Figure 22: Ordering Information

Ordering Code	Package	Туре	Delivery Form	Delivery Quantity
TSL250RD-TR	SOIC-8	D	Tape & Reel	1000 pcs/reel
TSL251RD-TR	SOIC-8	D	Tape & Reel	1000 pcs/reel
TSL260RD-TR	SOIC-8	D	Tape & Reel	1000 pcs/reel
TSL261RD-TR	SOIC-8	D	Tape & Reel	1000 pcs/reel

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## **Document Status**

Document Status	Product Status	Definition
Product Preview	Pre-Development	Information in this datasheet is based on product ideas in the planning phase of development. All specifications are design goals without any warranty and are subject to change without notice
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# **Revision Information**

Changes from 050K (2007-Oct) to current revision 1-00 (2016-Jun-07)	Page
Content of TAOS datasheet was converted to the latest <b>ams</b> design	
Updated Key Benefits & Features	1
Added Ordering Information	19

#### 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**

- 1 General Description
- 2 Key Benefits & Features
- 3 Functional Block Diagram
- 4 Pin Assignments
- 5 Absolute Maximum Ratings
- 6 Electrical Characteristics
- 9 Parameter Measurement Information
- **10** Typical Characteristics

#### 14 Application Information

- 14 Power Supply Considerations
- 14 Device Operational Details
- 15 PCB Pad Layout

### 16 Packaging Mechanical Data

### **18 Manufacturing Information**

- 19 Moisture Sensitivity
- 19 For devices shipped in tubes:
- 19 For devices shipped in carrier tape:
- 20 RoHS Compliant & ams Green Statement
- 21 Ordering & Contact Information
- 22 Copyrights & Disclaimer