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 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.

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	• Output Rise-Time Response, Typically
	  • 260µs (TSL250RD, TSL260RD)
	  • 70µs (TSL251RD, TSL261RD)

• Provides for High Sensitivity to Detect a Small Change in Light	• High Irradiance Responsivity, Typically
	  • 64mV/(µW/cm^2) @ λp = 640nm (TSL250RD)
	  • 58mV/(µW/cm^2) @ λp = 940nm (TSL260RD)

• Reduces Board Space Requirements while Simplifying Designs	• 5mm x 6.2mm SOIC (D) Package

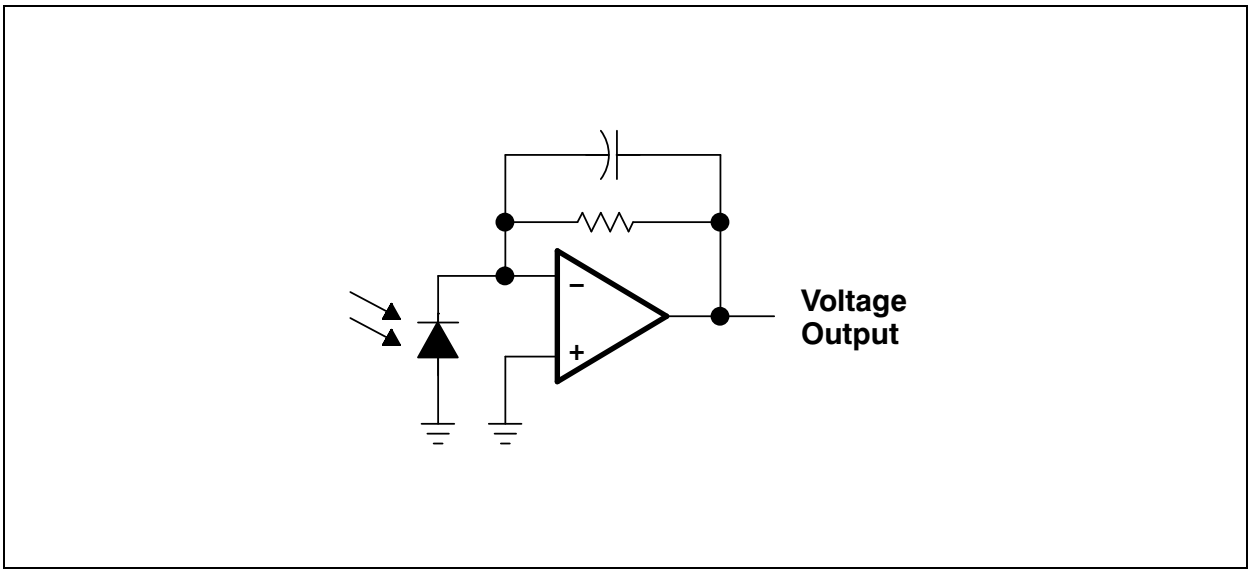
- Monolithic Silicon IC Containing Photodiode, Operational Amplifier, and Feedback Components
- Converts Light Intensity to a Voltage
- Single Voltage Supply Operation
- Low Dark (Offset) Voltage (10mV Max)
- Low Supply Current (1.1mA Typical)

- 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)

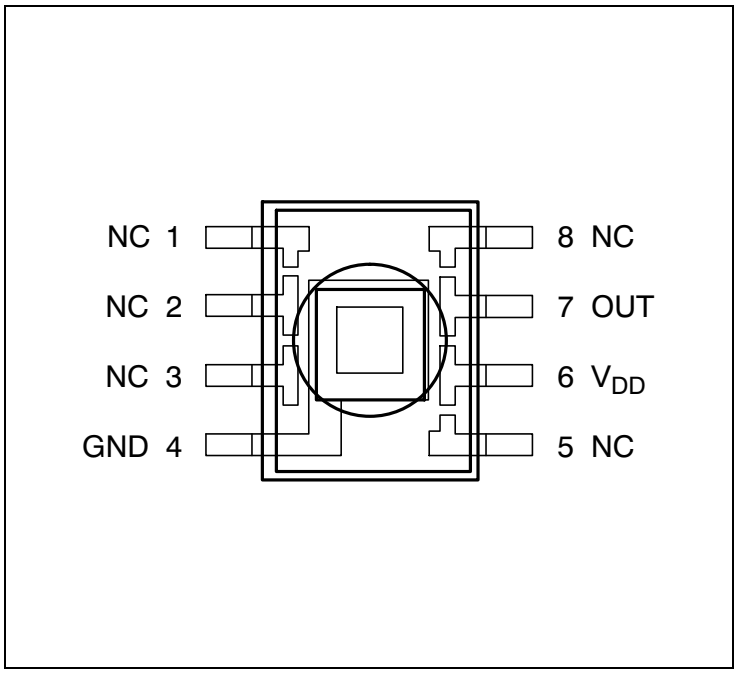


Figure 4:
Terminal Functions

Terminal		Description
Name	No.	
GND	4	Ground (substrate) All voltages are referenced to GND.
V_{DD}	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	Max	Unit
V_{DD}	Supply voltage (1)		6	V
I_O	Output Current		±10	mA
	Duration of short-circuit current at (or below) 25°C (2)		5	s
T_A	Operating free-air temperature range	-25	85	°C
T_{STRG}	Storage temperature range	-25	85	°C
	Solder conditions in accordance with JEDEC J-STD-020A, maximum temperature (3)		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	Max	Unit
V_{DD}	Supply voltage	2.7		5.5	V
T_A	Operating free-air temperature	0		70	°C

Figure 7:
Electrical Characteristics, V_{DD} = 5V, T_A = 25°C, R_L=10kΩ (unless otherwise noted) (1) (2) (3) (4)

Symbol	Parameter	Test Conditions	λ_p = 640nm						λ_p = 940nm						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} = 4.5V	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/‘				1.5	2	2.5							
		E_e = 34 µW/cm^2							1	2	3				
		E_e = 132 µW/cm^2										1	2	3	

Symbol	Parameter	Test Conditions	λ_p = 640nm						λ_p = 940nm						Unit
			TSL250RD			TSL251RD			TSL260RD			TSL261RD			
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
R_e	Irradiance responsivity	See note (4)		64			16			58			15		mV/ ($\mu W/cm^2$)
	Temperature coefficient of output voltage (V_O)	V_O = 2V @ 25°C T_A = 0°C to 70°C, (5)		2			2			8			8		mV/°C
				0.1			0.1			0.4			0.4		%/°C
I_{DD}	Supply current	E_e = 31 $\mu W/cm^2$		1.1	1.7										mA
		E_e = 124 $\mu W/cm^2$					1.1	1.7							
		E_e = 34 $\mu W/cm^2$								1.1	1.7				
		E_e = 132 $\mu W/cm^2$											1.1	1.7	

Note(s):

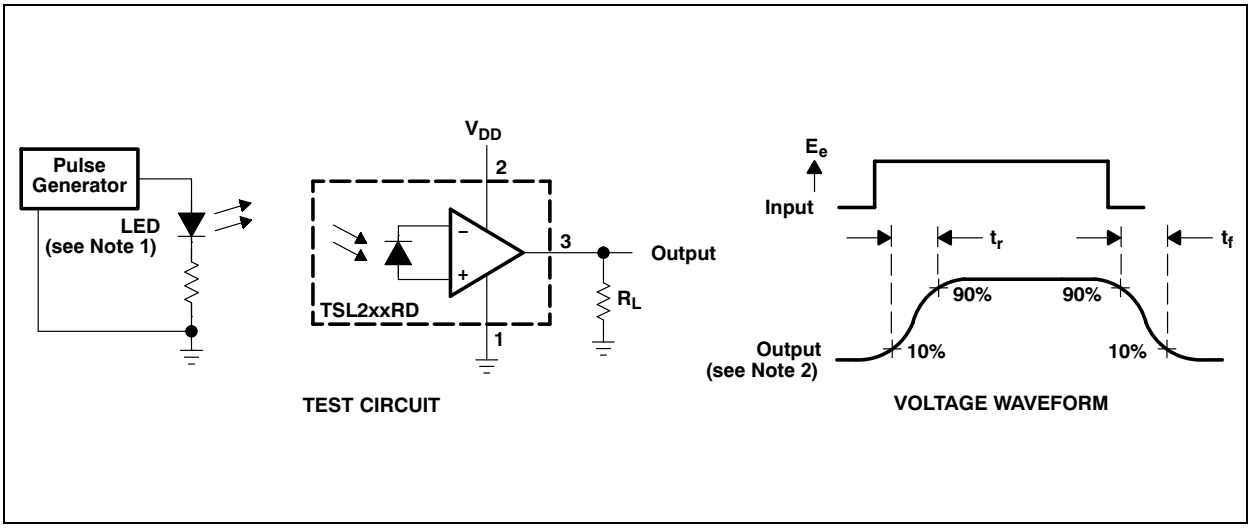
1. Measurements are made with R_L = 10kΩ between output and ground.
2. Optical measurements are made using small-angle incident radiation from an LED optical source.
3. The 640nm input irradiance E_e is supplied by an AlInGaP LED with peak wavelength λ_p = 640nm.
4. The 940nm input irradiance E_e is supplied by a GaAs LED with peak wavelength λ_p = 940nm.
5. Irradiance responsivity is characterized over the range $V_O = V_D$ to 3V. 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.
6. The temperature coefficient of output voltage measurement is made by adjusting irradiance such that V_O is approximately 2V at 25°C and then with irradiance held constant, measuring V_O while varying the temperature between 0°C and 70°C.

Figure 8:
Dynamic Characteristics, V_{DD} = 5V, T_A = 25°C, R_L=10kΩ (unless otherwise noted) (see Figure 9)

Symbol	Parameter	Test Conditions	λ_p = 640nm						λ_p = 940nm						Unit
			TSL250RD			TSL251RD			TSL260RD			TSL261RD			
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
t_r	Output pulse rise time	$V_{O(peak)}$ = 2V		260			70			260			70		µs
t_r	Output pulse fall time	$V_{O(peak)}$ = 2V		260			70			260			70		µs
V_n	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: $t_r < 100ns$, $Z_i \geq 1M\Omega$, $C_i \leq 20pF$.

Typical Characteristics

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

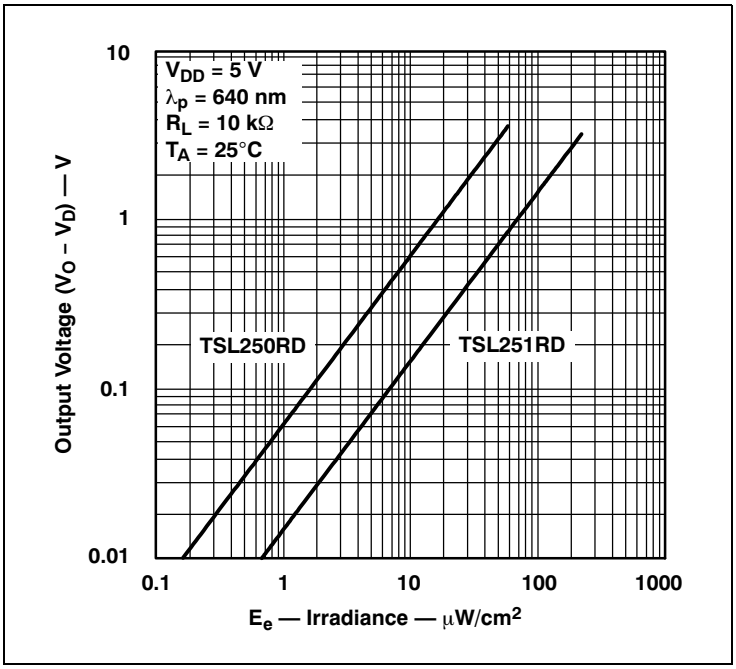


Figure 11:
Output Voltage vs. Irradiance (TSL260RD, TSL261RD)

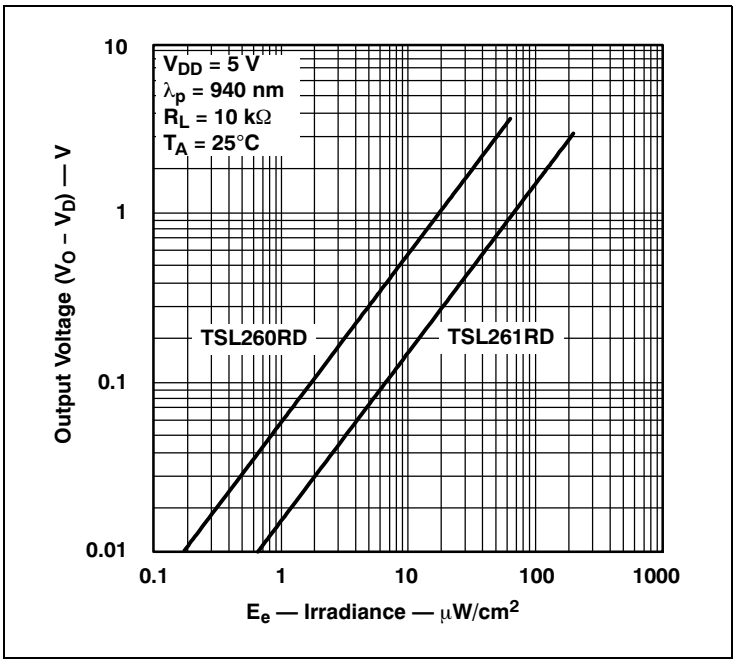


Figure 12:
Photodiode Spectral Responsivity (TSL250RD, TSL251RD)

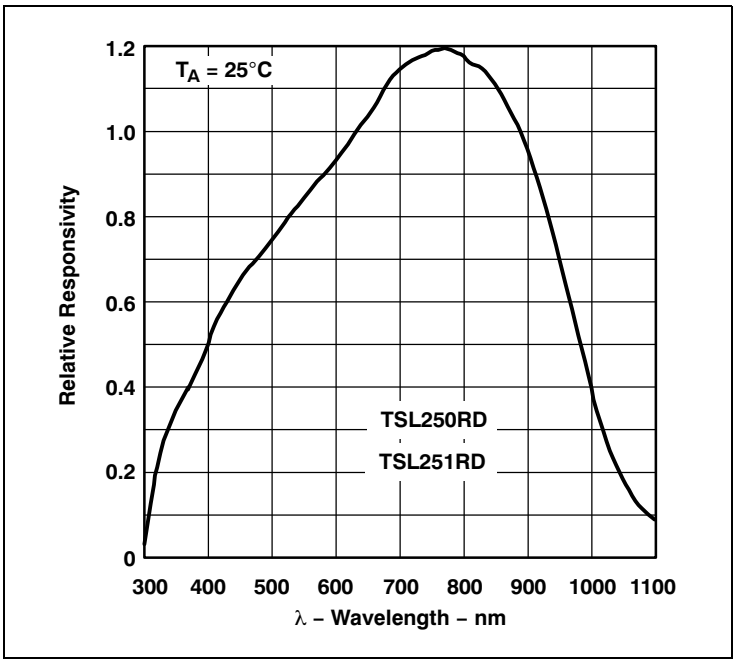


Figure 13:
Photodiode Spectral Responsivity (TSL260RD, TSL261RD)

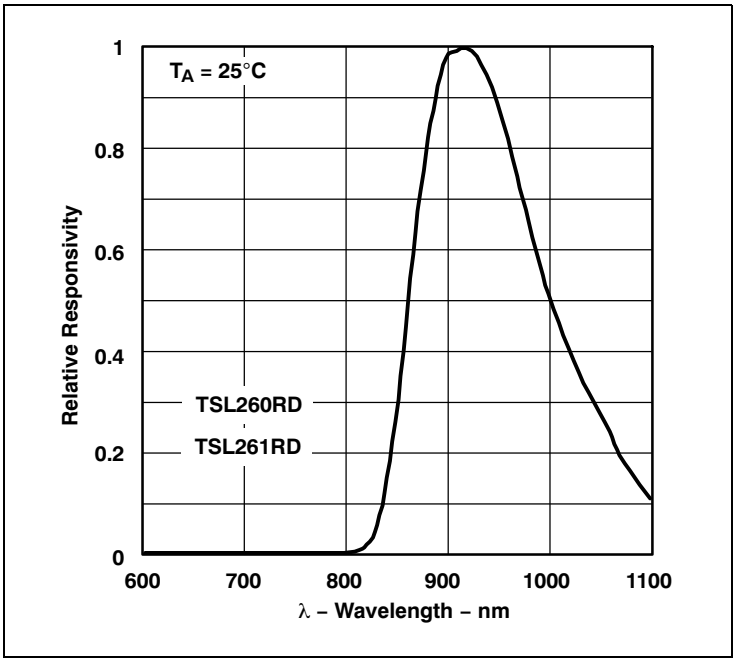


Figure 14:
Maximum Output Voltage vs. Supply Voltage

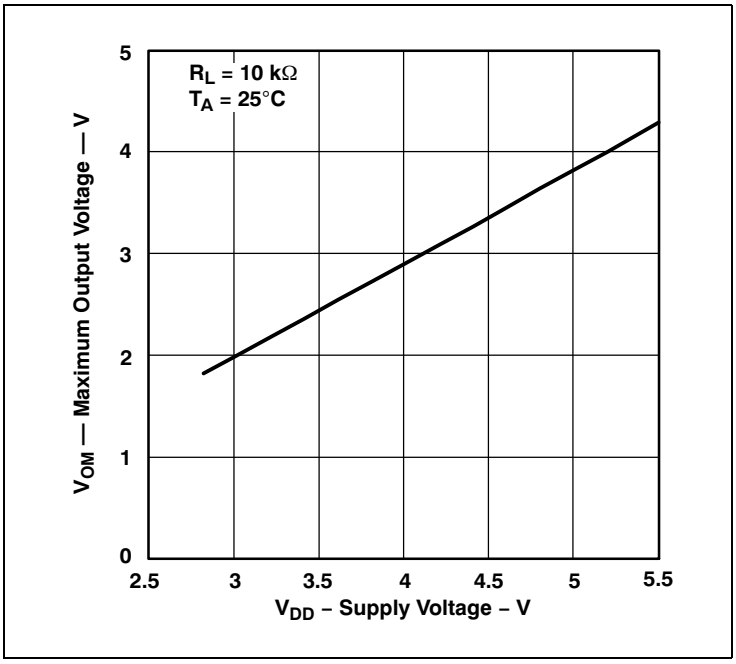


Figure 15:
Supply Current vs. Output Voltage

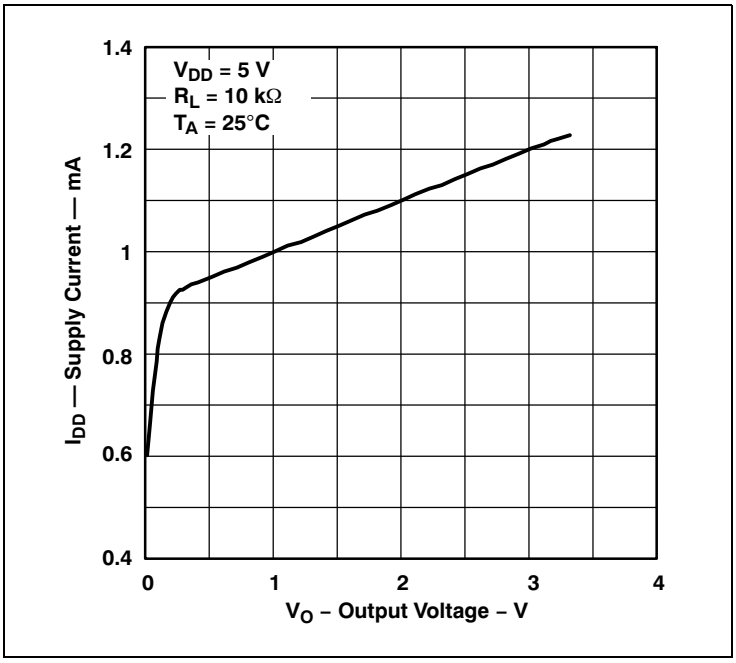
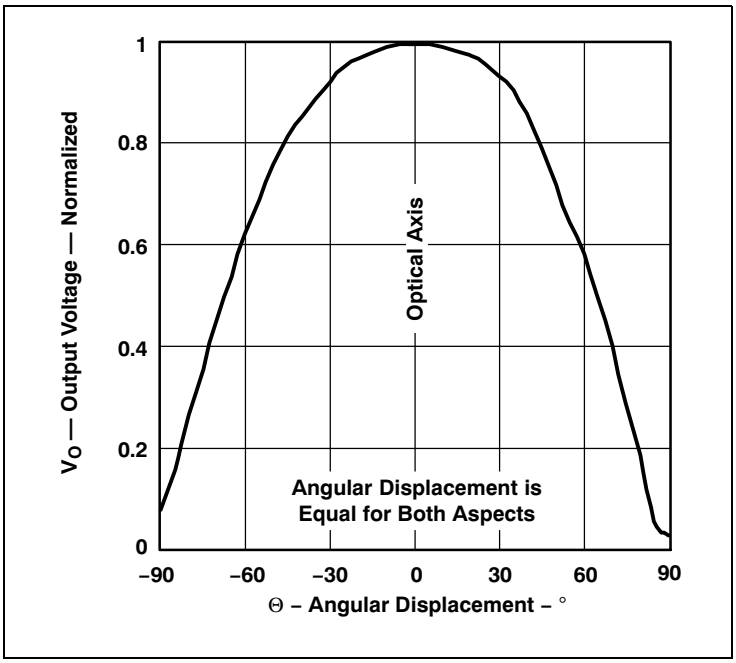


Figure 16:
Normalized Output Voltage vs. Angular Displacement



Application Information

Power Supply Considerations

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

Device Operational Details

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

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

where:

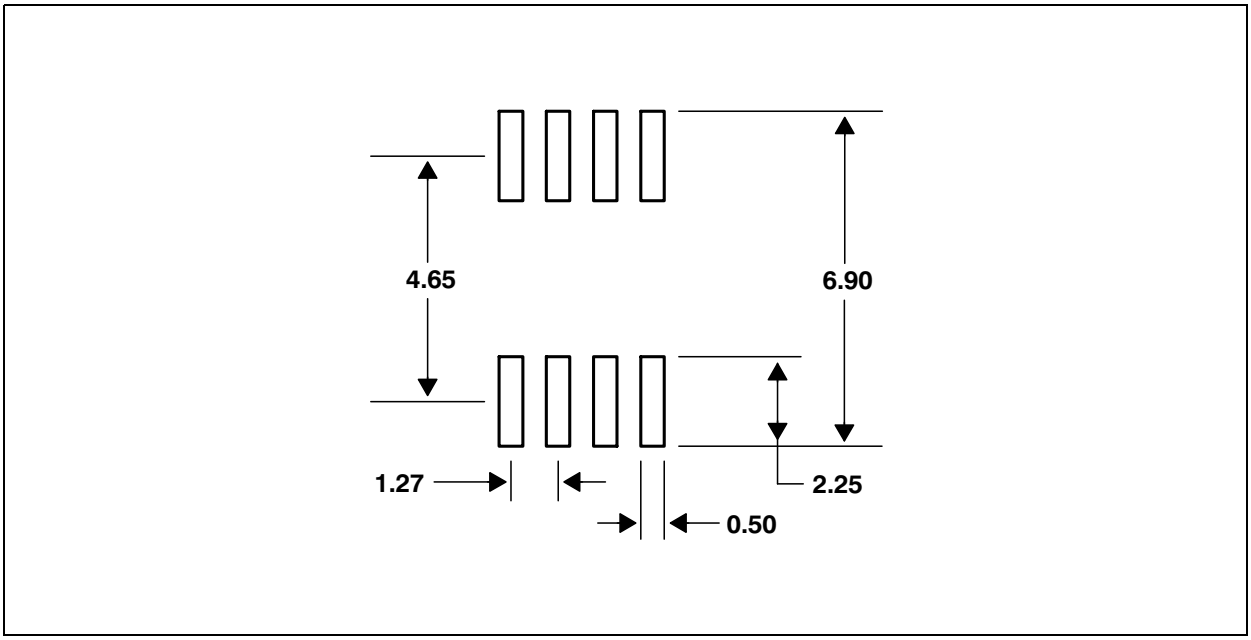
- V_O is the output voltage
- V_D is the output voltage for dark condition ($E_e = 0$)
- R_e is the device responsivity for a given wavelength of light given in mV/(µW/cm^2)
- E_e is the incident irradiance in µW/cm^2

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 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



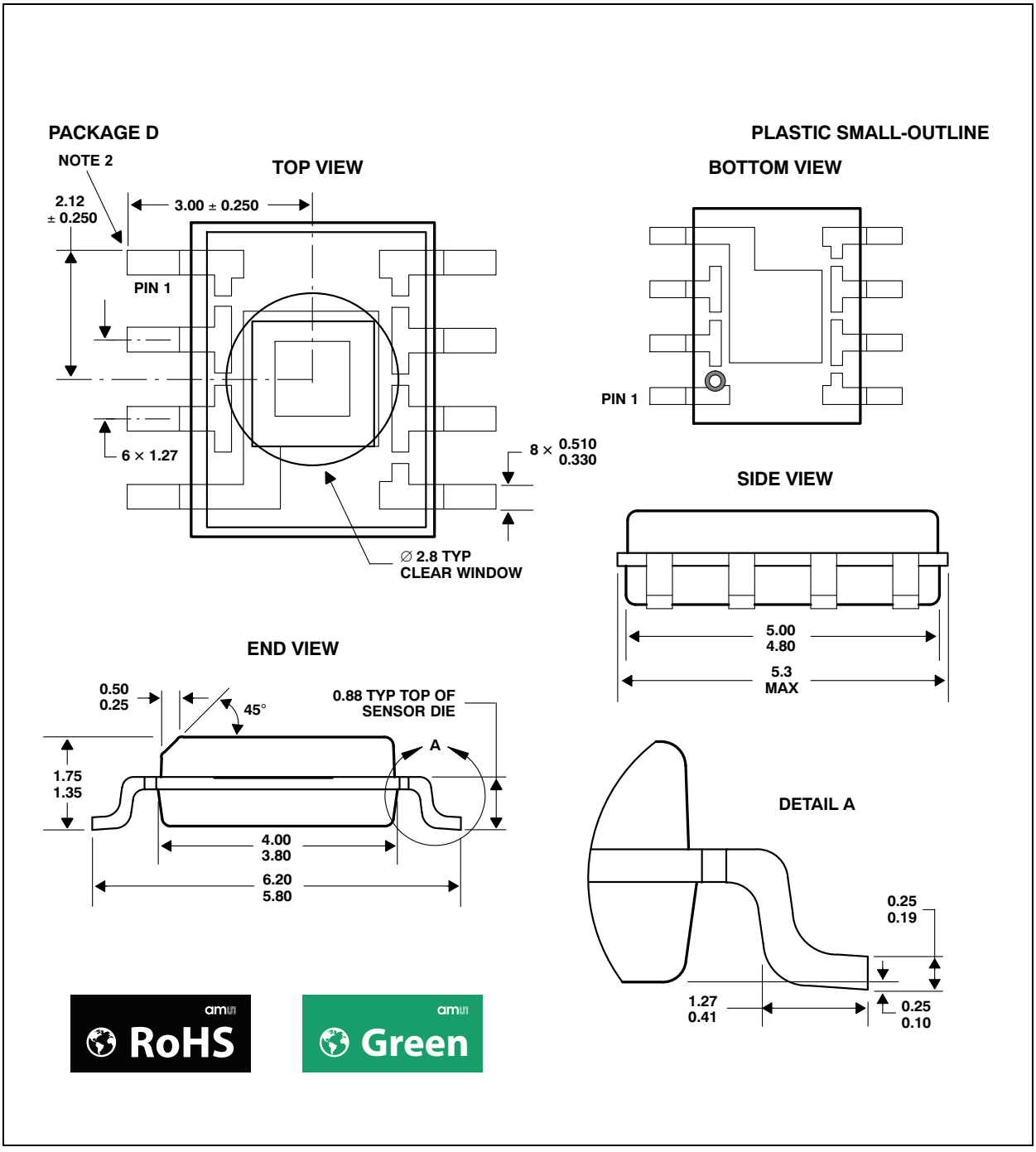
Note(s):

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^2 for the TSL250RD and TSL260RD, and is typically 0.514mm^2 for the TSL251RD and TSL261RD.

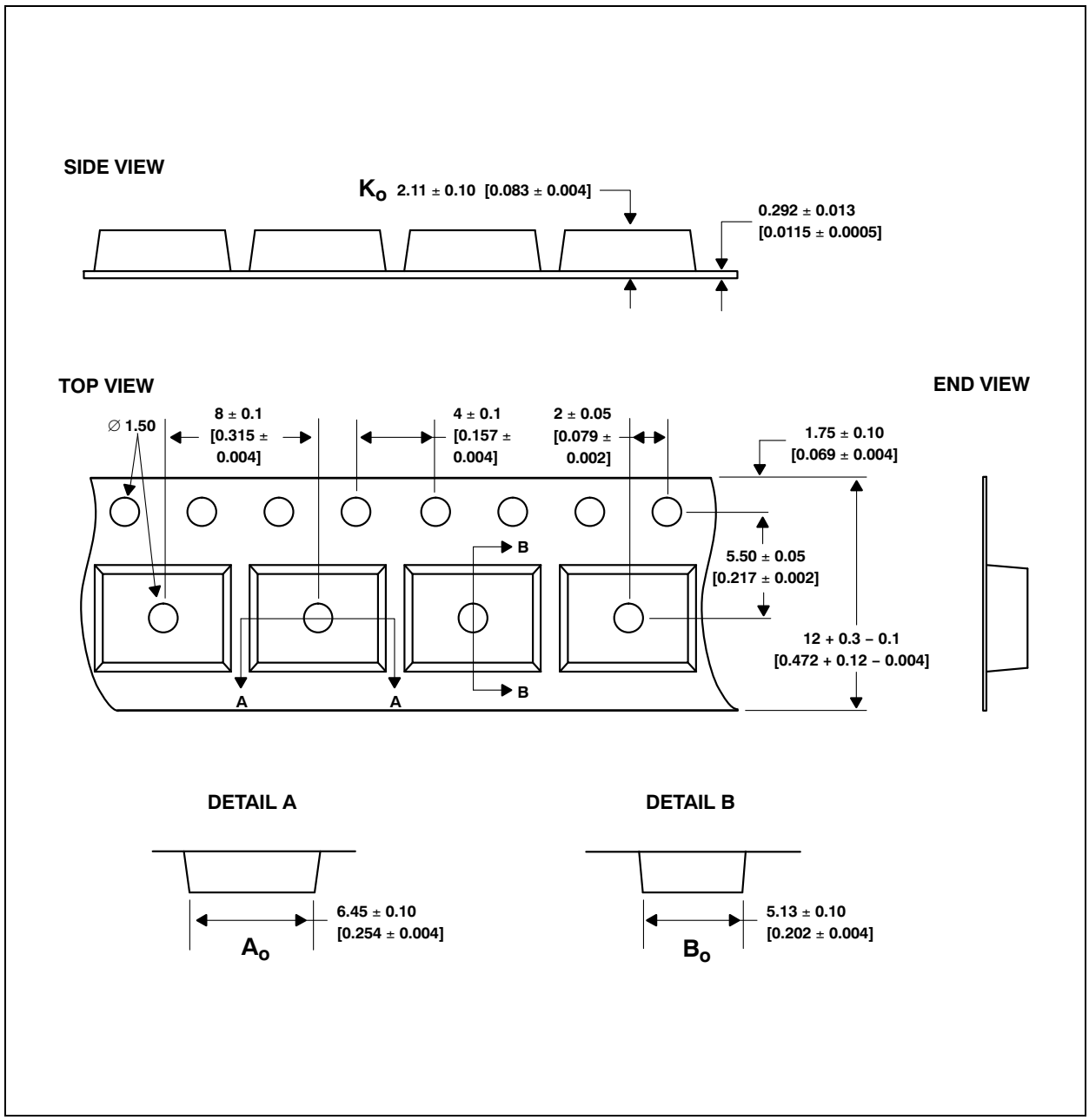
Figure 18:
Package D - Plastic Small-Outline IC Packaging Configuration



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

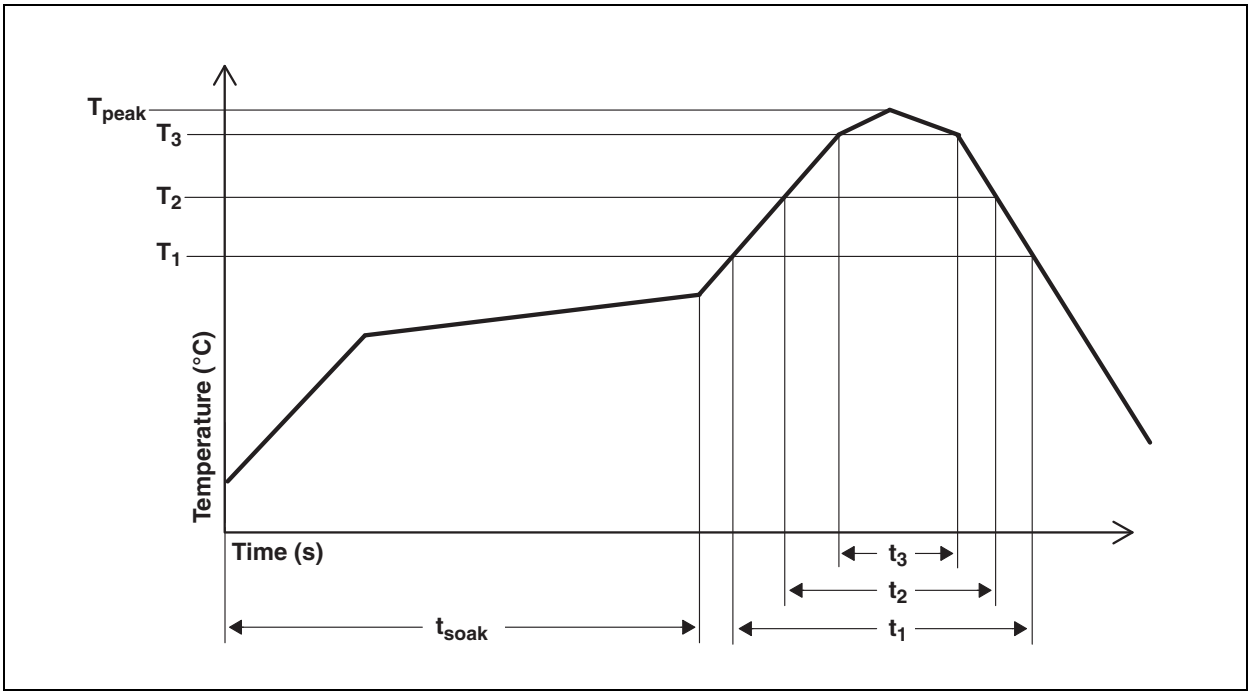
The Plastic Small Outline IC package (D) has been tested and has demonstrated an ability to be reflow soldered to a PCB substrate.

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_{soak}	2 to 3 minutes
Time above 217°C	t_1	Max 60 s
Time above 230°C	t_2	Max 50 s
Time above T_{peak} - 10°C	t_3	Max 10 s
Peak temperature in reflow	T_{peak}	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.

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	Type	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

Buy our products or get free samples online at:
www.ams.com/ICdirect

Technical Support is available at:
www.ams.com/Technical-Support

Provide feedback about this document at:
www.ams.com/Document-Feedback

For further information and requests, e-mail us at:
ams_sales@ams.com

For sales offices, distributors and representatives, please visit:
www.ams.com/contact

Headquarters
ams AG
Tobelbaderstrasse 30
8141 Premstaetten
Austria, Europe

Tel: +43 (0) 3136 500 0

Website: www.ams.com

RoHS Compliant & ams Green Statement

RoHS: The term RoHS compliant means that ams AG products fully comply with current RoHS directives. Our semiconductor products do not contain any chemicals for all 6 substance categories, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, RoHS compliant products are suitable for use in specified lead-free processes.

ams Green (RoHS compliant and no Sb/Br): ams Green defines that in addition to RoHS compliance, our products are free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material).

Important Information: The information provided in this statement represents ams AG knowledge and belief as of the date that it is provided. ams AG bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. ams AG has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. ams AG and ams AG suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

Copyrights & Disclaimer

Devices sold by ams AG are covered by the warranty and patent indemnification provisions appearing in its General Terms of Trade. ams AG makes no warranty, express, statutory, implied, or by description regarding the information set forth herein. ams AG reserves the right to change specifications and prices at any time and without notice. Therefore, prior to designing this product into a system, it is necessary to check with ams AG for current information. This product is intended for use in commercial applications. Applications requiring extended temperature range, unusual environmental requirements, or high reliability applications, such as military, medical life-support or life-sustaining equipment are specifically not recommended without additional processing by ams AG for each application. This product is provided by ams AG “AS IS” and any express or implied warranties, including, but not limited to the implied warranties of merchantability and fitness for a particular purpose are disclaimed.

ams AG shall not be liable to recipient or any third party for any damages, including but not limited to personal injury, property damage, loss of profits, loss of use, interruption of business or indirect, special, incidental or consequential damages, of any kind, in connection with or arising out of the furnishing, performance or use of the technical data herein. No obligation or liability to recipient or any third party shall arise or flow out of ams AG rendering of technical or other services.

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
Preliminary Datasheet	Pre-Production	Information in this datasheet is based on products in the design, validation or qualification phase of development. The performance and parameters shown in this document are preliminary without any warranty and are subject to change without notice
Datasheet	Production	Information in this datasheet is based on products in ramp-up to full production or full production which conform to specifications in accordance with the terms of ams AG standard warranty as given in the General Terms of Trade
Datasheet (discontinued)	Discontinued	Information in this datasheet is based on products which conform to specifications in accordance with the terms of ams AG standard warranty as given in the General Terms of Trade, but these products have been superseded and should not be used for new designs

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 **ams** 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