Ultra-small Ambient Light Sensor
Linear Current Output,
2-Stage Gain Switching
using the LA0151CS

Overview
The LA0151CS is a photo IC for micro-sized ambient light sensor. It enables to be mounted on a very small limited space such as on the cell phones which is becoming small and thinner and on other mobile applications. It is suitable for application like mobile phone, tablet PC, digital still camera and camcorder.

Features
- Smallest ODCSP package in the world (1.01mm x 1.01mm, thickness : 0.6mm)
- Low gain mode function (Low gain -38dB)
- Low power consumption (150μA at 1,000Lux)
- Low dark current (Max current 0.1μA)
- No sensibility in infrared area
- Less difference in sensibility depending on the type of light source (Fluorescent/Incandescent:1.0/1.1)
- Linear current output
- Wide dynamic range (1 to 100,000Lux)
- Halogen free compliant

Pin Assignment

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VCC</td>
<td>Power supply</td>
</tr>
<tr>
<td>2</td>
<td>SW</td>
<td>Gain change</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>OUT</td>
<td>Output</td>
</tr>
</tbody>
</table>

Ball Pitch : 0.5mm , Ball Size : 0.18mm
Pad Layout (Photos)

Photo diode: Only this part looks dark.

Recommended Land Pattern

unit: μm

Land (pink): 300μm square
Solder resist opening (green): 400μm square

Block Diagram

Current Amp.
VCC 1
OUT 4
SW 2
GND 3
Chip Pattern and Photo-receiving Pattern Diagrams

ODCSP Cross Section Structure

**Optical Device Chip Size Package**

ON Semiconductor original wafer level package for optical device.
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS at Ta=25°C (Note 1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Ratings</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum supply voltage</td>
<td>VCC</td>
<td>6 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>Topr</td>
<td>-30 to 85 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>Tstg</td>
<td>-40 to 100 °C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Stresses exceeding those listed in the Absolute Maximum Rating table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

#### RECOMMENDED OPERATING CONDITIONS AND OPERATING VOLTAGE RANGE at Ta=25 °C (Note 2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended supply voltage</td>
<td>VCC</td>
<td></td>
<td>2.2</td>
<td>3.3</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>SW pin low voltage</td>
<td>VI</td>
<td>Normal gain mode</td>
<td>0</td>
<td>0.4</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>SW pin high voltage</td>
<td>Vh</td>
<td>Low gain mode</td>
<td>1.4</td>
<td></td>
<td>VCC</td>
<td>V</td>
</tr>
</tbody>
</table>

2. Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

#### ELECTRICAL AND OPTICAL CHARACTERISTICS at VCC=3.3V, Ta=25 °C (Note 3)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current dissipation (Note 4,6)</td>
<td>ICC</td>
<td>Ev=1000 lux, RL=5kΩ</td>
<td>90</td>
<td>150</td>
<td>210</td>
<td>μA</td>
</tr>
<tr>
<td>Sleep current (1) (Note 6)</td>
<td>Isl1</td>
<td>Ev=0 lux</td>
<td>0.1</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Sleep current (2) (Note 6)</td>
<td>Isl2</td>
<td>Ev=1000 lux</td>
<td>0.3</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Output current (1) (Note 4,6)</td>
<td>IO1</td>
<td>Ev=100 lux</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>μA</td>
</tr>
<tr>
<td>Output current (2) (Note 4,6)</td>
<td>IO2</td>
<td>Ev=1000 lux</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>μA</td>
</tr>
<tr>
<td>Dark current (Note 6)</td>
<td>Ileak</td>
<td>Ev=0 lux</td>
<td>0.1</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Temperature coefficient (Note 5)</td>
<td>Itc</td>
<td>Ev=100 lx, Ta=20 to 60°C</td>
<td>0.34</td>
<td></td>
<td>% /°C</td>
<td></td>
</tr>
<tr>
<td>Rise time (1) (Note 7)</td>
<td>Tr1</td>
<td>Ev=1000 lux, RL=5kΩ</td>
<td>15</td>
<td>40</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>Fall time (1) (Note 7)</td>
<td>Tt1</td>
<td>Ev=1000 lux, RL=5kΩ</td>
<td>150</td>
<td>500</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>Peak sensitivity wave length (Note 5)</td>
<td>A\text{p}</td>
<td></td>
<td>550</td>
<td></td>
<td>nm</td>
<td></td>
</tr>
<tr>
<td>Saturation output voltage (Note 4,6)</td>
<td>V\text{O}</td>
<td>R\text{L}=150kΩ, Ev=1000 lx</td>
<td>3.0</td>
<td>3.2</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

3. Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

4. Measured with the standard light source A. White LED is used instead in the mass production line.

5. Design guaranteed item

6. Test circuit for measuring current dissipation and output current

![Test Circuit Diagram](image-url)
7. Measuring method of rise time (Tr) and fall time (Tf)
Typical Performance Characteristics

Output current - Illuminance

Consumption current - Illuminance

Ileak - Ambient temperature
Output Voltage - Illuminance (Vcc=3.3V, RL=15K)

Illuminance E_v [lx] vs. Output Voltage [V]

Relative Spectral Responsivity

Lambda [nm] vs. Relative Spectral Sensitivity

Directional Sensitivity: Normal Gain @1000lx

Degree [°] vs. Directional Sensitivity
Sample Application Circuit

You can regulate the output voltage of the light sensitivity by an output resistance value. Please adjust it by application.

\[ V_{out} = (80 \mu A \text{ at 1000lx, Normal mode}) \times EV \times R_l \]

You can compose LPF by connecting capacity to the output. This is to reduce the 50/60Hz noise of the AC power.

\[ C_l = \frac{1}{(2 \pi f_c R_l)} \]

It is not necessary to place power supply capacity near an IC. The power supply capacity recommends from 0.01\( \mu \)F to 0.1\( \mu \)F.

*The receiving photoresponse changes depending on the distance from the diameter, the material, and the case to IC of the sensor window etc. Therefore, the optimum setting is necessary for resistance and the capacity value between 4 pin(OUT) and 3 pin(GND) according to the application.*
## Pin Functions

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Pin function</th>
<th>Equivalent Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VCC</td>
<td>Power supply terminal. Insert a capacitor between this pin and ground to prevent the influence of noise, etc.</td>
<td><img src="image1.png" alt="Equivalent Circuit" /></td>
</tr>
<tr>
<td>2</td>
<td>SW</td>
<td>Gain change terminal. This pin is used for gain change. When this pin is low, &quot;Normal gain&quot;. When this pin is high, &quot;Low gain&quot;.</td>
<td><img src="image2.png" alt="Equivalent Circuit" /></td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td>Ground terminal.</td>
<td><img src="image3.png" alt="Equivalent Circuit" /></td>
</tr>
<tr>
<td>4</td>
<td>OUT</td>
<td>Output terminal. This pin is outputted the linear current depending on ambient light.</td>
<td><img src="image4.png" alt="Equivalent Circuit" /></td>
</tr>
</tbody>
</table>
Relative Output Current vs Distance

- Measuring method

![Diagram of measurement setup](image)

- Evaluation result

![Graph showing relative output current vs distance](image)

- Recommended condition
  
  Hole size $\phi$ (optical window) = more than 2mm.
  
  Distance from sensor to optical window = less than 2mm.
Light Source Dependency

*Fluorescent light is set to “1”

Dynamic Current Range
Dynamic Voltage Range

**Output Voltage - Illuminance (logarithm)**

\( \text{Vcc}=2.6\text{V, Standard A Light} \)

**Output Voltage - Illuminance (linear)**

\( \text{Vcc}=2.6\text{V, Standard A Light} \)
Differential Light Sensibility by PD Location

< Side view >

Sensor window

light

Plastic (black : transmission factor=0)

Board (glass epoxy)

< Top view >

A : PD is arranged at the center of the sensor window.
B to E : The position of PD was rotated.

PD location dependency

PD location A is set to “1”
Window design guide

Flat window lens design

A window lens will surely limit the viewing angle of the LA0151CS. The window lens should be placed directly on top of the LA0151CS. The thickness of the lens should be kept at minimum to minimize loss of power due to reflection and also to minimize loss of loss due to absorption of energy in the plastic material. A thickness of \( T = 1 \ \text{mm} \) is recommended for a window lens design.

Window with light pipe design

If a smaller window is desired while maintaining a wide effective viewing angle of the LA0151CS, a cylindrical piece of transparent plastic is needed to trap the light and then focus and guide the light on to the LA0151CS. Hence the name light guide or also known as light pipe. The pipe should be placed directly on top of the LA0151CS with a distance of \( Z = 0.5 \ \text{mm} \) to achieve peak performance. The light pipe should have minimum of 1.5mm in diameter to ensure that whole area of the sensor will be exposed.

![Diagram of flat window lens and window with light pipe]

<table>
<thead>
<tr>
<th>WD ((T+L+Z))</th>
<th>FLAT WINDOW LENS ((L=0.0))</th>
<th>WINDOW WITH LIGHT PIPE ((D2=1.5, Z=0.5))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>D1</td>
<td>D1</td>
</tr>
<tr>
<td>1.5</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>2.0</td>
<td>1.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2.5</td>
<td>1.5</td>
<td>4.0</td>
</tr>
<tr>
<td>3.0</td>
<td>2.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

*All dimensions are in mm.
*These dimensions are based on a window lens thickness of 1.0mm and a refractive index of 1.59.

**WD**: Distance between window front panel and LA0151CS  
**D1**: Window diameter, **T**: Thickness, **L**: Length of light pipe  
**D2**: Light pipe diameter, **Z**: Distance between window rear panel and LA0151CS
Evaluation Board Manual

Evaluation Board

- Photo Diode
- I.C.
- R1 33kΩ
- C1 0.1µF
- 4pin OUT
- 3pin VCC
- 2pin SW
- 3pin GND

<table>
<thead>
<tr>
<th>SW</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Normal gain</td>
</tr>
<tr>
<td>High</td>
<td>Low gain</td>
</tr>
</tbody>
</table>
Test Procedure:
1. Connect the test setup as shown above.
2. Connect IC power supply (2.2V to 5.5V) between VCC and GND.
3. Connect multimeter between OUT and GND.
4. Irradiate a light, and put on the illuminance meter near the IC.
5. Control the light source and to be adjusted 500 lux.
6. Then, OUT terminal of LA0151CS is outputted roughly 40\(\mu\)A. Therefore, multimeter is showed roughly 1.32V. (1.32V = 40\(\mu\)A\times33\(\Omega\))

LA0151CS features:
- No sensibility in infrared area.
- Less difference in sensibility depending on the type of light source.
  (Please see to page 11 “Light Source Dependency”.)

Evaluation Board Circuit Diagram
## Bill of Materials for LA0151CS Evaluation Board

<table>
<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Description</th>
<th>Value</th>
<th>Tolerance</th>
<th>Footprint</th>
<th>Manufacturer</th>
<th>Manufacturer Part Number</th>
<th>Substitution Allowed</th>
<th>Lead Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1</td>
<td>1</td>
<td>Ambient Light Sensor</td>
<td>-</td>
<td>-</td>
<td>ODCSP4 (0.5mm,pitch)</td>
<td>ON Semiconductor</td>
<td>LA0151CS</td>
<td>No</td>
<td>yes</td>
</tr>
<tr>
<td>R1</td>
<td>1</td>
<td>OUT (to GND)</td>
<td>33k (0.063W)</td>
<td>±5%</td>
<td>1005 (0402inch)</td>
<td>ROHM</td>
<td>MCR01MZPJ333</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>C1</td>
<td>1</td>
<td>VCC Bypass Capacitor</td>
<td>0.1uF /16V</td>
<td>±10%</td>
<td>1005 (0402inch)</td>
<td>MURATA</td>
<td>GRM155B11C104KA</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

### Evaluation Board PCB Design

(Top View)

![Pattern](image1.png)

![Resist](image2.png)

![Silk](image3.png)

![Chart](image4.png)

**Specified circuit board**

- 6×10×0.5mm
- One layer glass epoxy

**Pdmax - Ta**

- Allowable power consumption Pdmax (mW)
- Ambient temperature Ta (°C)

- Pdmax - Ta

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18
Packing Specification of Embossed Carrier Taping
ODCSP4 (1.01X1.01)

1. EMBOSSED CARRIER TAPING

1-1. Emboss carrier tape dimensions

1-2. Tape mounting direction

1-3. Reel winding start and reel winding end

2. TAPE STRENGTH

2-1. Tensile strength of the carrier tape: Min. 10N

2-2. Peel strength of the top cover tape
   (a) Peel angle: 165° to 180° relative to the tape adhesive surface
   (b) Peel rate: 300mm/minute
   (c) Peel of strength: 0.1N to 1.0N
3. PARTS No. ON BAR CODE LABEL

- Type number
- Taping symbol
- H

LEAD FREE and HALOGEN FREE symbol
Direction indication

4. REEL DIMENSIONS

MODEL: RRM-08B
UNIT: mm
<table>
<thead>
<tr>
<th>Carrier tape type number</th>
<th>Package code</th>
<th>Maximum number of IOs contained (pos.)</th>
<th>Packing form</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARR(WLF1X1X75)</td>
<td>0DSP4(1.01X1.01)</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Reels contained</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dimensions: mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>150 x 37 x 150</td>
<td></td>
</tr>
</tbody>
</table>

**PN Label**

**Packing Method**

1. MPN Label
2. MPN Label
3. Aluminium laminating bag
4. Desiccant
5. Thermal seal
6. Cellulose tapeing
7. Put 1 Reel into inner box
# Lineup of Ambient Light Sensor

<table>
<thead>
<tr>
<th>Product name</th>
<th>LA0151CS</th>
<th>LA0152CS</th>
<th>LV0111CF</th>
<th>LV0104CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output type</td>
<td>Linear current</td>
<td>Linear current</td>
<td>Logarithm current</td>
<td>16bitAD digital</td>
</tr>
<tr>
<td>Overall size(mm)</td>
<td>1.01×1.01×0.6</td>
<td>1.01×1.01×0.6</td>
<td>1.08×1.08×0.6</td>
<td>1.08×1.08×0.6</td>
</tr>
<tr>
<td>Spectral characteristics</td>
<td>Normal</td>
<td>Normal</td>
<td>Closer to visibility</td>
<td>Closer to visibility</td>
</tr>
<tr>
<td>Gain switching</td>
<td>○</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Standby function</td>
<td>—</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Operating voltage (V)</td>
<td>2.2 to 5.5</td>
<td>2.2 to 5.5</td>
<td>2.3 to 5.5</td>
<td>2.3 to 3.6</td>
</tr>
<tr>
<td>Operating temperature range (°C)</td>
<td>—30 to 85</td>
<td>—30 to 85</td>
<td>—30 to 85</td>
<td>—30 to 85</td>
</tr>
<tr>
<td>Consumption current 1000 lx</td>
<td>150uA</td>
<td>150uA</td>
<td>75uA</td>
<td>70uA</td>
</tr>
<tr>
<td>Output current 100 lx</td>
<td>8uA</td>
<td>8uA</td>
<td>20uA</td>
<td>100 counts</td>
</tr>
<tr>
<td>Output current 1000 lx</td>
<td>80uA</td>
<td>80uA</td>
<td>30uA</td>
<td>1000 counts</td>
</tr>
<tr>
<td>Peak sensitivity (nm)</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>D range</td>
<td>1 to 100k lx</td>
<td>1 to 100k lx</td>
<td>1 to 100k lx</td>
<td>1 to 65k lx</td>
</tr>
<tr>
<td>Pb free</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Halogen free</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Status</td>
<td>Mass production</td>
<td>Mass production</td>
<td>Mass production</td>
<td>Mass production</td>
</tr>
</tbody>
</table>

![Graph LA0151CS/LA0152CS](image1)

![Graph LV0111CF/LV0104CS](image2)

Human eye